JOURNAL OF THE INSTITUTION OF CIVIL ENGINEERS.

No. 3. 1939–40.
JANUARY 1940

ORDINARY MEETING.

21 November, 1939.

CLEMENT DANIEL MAGGS HINDLEY, K.C.I.E., M.A., President, in the Chair.

he Council reported that they had recently transferred to the class of

Members.

AOS MICHAEL BOSTANDJI, B.Sc. s.).
E WILLIAM COVER.
ALEXANDER DAVIDSON, B.E. (*Bel-*
.
AM HOWARD JOHNSON, M.A. (*Can-*
.
JAMES REED, B.Sc. (*Edin.*).
JOHN MAWSON ROUNTHWAITE, B.Sc. (*Durham*).
ALFRED OBRÉ WHITEHOUSE, B.Sc. (Eng.) (*Lond.*).

ad admitted as

Students.

RD ADAMS, B.Sc. (*Leeds*).
AM HAROLD CLARK AITCHISON.
JOHN FRANCIS ALLEN-WILLIAMS, . (*Cantab.*).
SABAPATHY AMBALAVANAR.
IS ARNOT ANDERSON.
APPEL.
ATNAM RAJA ARULAMBALAM.
D ATKINSON, Jun.
BALL.
RICHARD BARBER, B.Sc. (*Birm-am*).
ON MILTON BARHAM.
AM BARNES.
OND BARRETT.
ES HAYWARD PETER BAYNTUN.
ARTHUR BAYS.
BEARD.
ES NORMAN BENOY.
HERBERT BEST.
NDER JOHN BLAKE.
JOHN EDWARD VALENTINE BLOMFIELD.
ROBERT WILLIAM BOTTJER.
WILLIAM RAGLAN PEDLOW BOWDEN.
ROBERT ANGUS BRIDGEFORD.
JAMES MACKAY BRUCE.
CECIL FRANK BRYER.
MALCOLM GRAHAM BURGESS.
ROBERT RANDOLPH HENRY BURSEY.
IAN DOUGLAS FOSTER CAMERON.
JAMES WATSON CAMERON.
DOUGLAS CARRICK.
WILLIAM JOHN CAPSTICK CAVE.
NEO POH CHOON.
EDUARD BERNARD CLOETE, B.Sc. (*Witwatersrand*).
REGINALD CHARLES COATES.
KENNETH PAUL GRAY COBB.
CHARLES THOMAS COLE.
JOHN LEWIS CRAIG.
ANTHONY WILLIAM ARTHUR CRAWSHAWE.
NOËL VICTOR CROSS.

Robert Ernest Dawson, B.Sc. (*Aberdeen*).
Arthur Francis Defferary, Jun.
Harry Dootson.
Rennie Frank Duggan.
Robert Duncan.
Philip David Edmondson.
Denys William England, B.Sc. (*Glas.*).
Hugh Duncan Findlay, B.Sc. (*Glas.*).
Charles Harold Allen Foster, B.Sc. (Eng.) (*Lond.*).
Geoffrey Beaumont Foster.
Kumarasingham Ganesan.
Chitta Priya Ghose, B.Sc. (*Calcutta*).
Bernard Richardson Goodsir.
Thomas William Gornall.
Cyril Goulborn.
Percy John Greaves, B.A. (*Cantab.*).
Edwin Leslie Gregory.
Raymond Gordon Rider Haggard.
Mervyn John Beaumont Haynes.
Gordon Nicol Henderson.
Geoffrey Arthur de Courcy Hillman, B.A. (*Oxon*), B.E. (*W. Australia*).
Douglas Judson Holmes.
Dennis Harold Honychurch.
Joseph Howat.
Frederick George Hutton.
William Imrie.
Fred Robert Jarvis.
Thomas Philip Johnstone.
Alan William Jones.
Subramaniam Kathirithamby.
Leo Thomas Bernard Kealey.
Lawrence Lee Kenchington.
Arthur Glanville Kennedy.
Kenneth Edwin Kevern.
Harold Carlon Laweson.
Hugh Richard Blair Leighton.
Howard Llewelyn Lewis.
Robert Arthur Drysdale Lindsay.
Stanley Grenville Wilfred Long.
Joseph Guy Lubbock, B.A. (*Cantab.*).
Malcolm Hugh Dees McAlpine.
Hamilton Blair McDowell.
John Falconer McFarlane.
Finlay Malcolm McNaughton.
Stanley Reginald Manners.
Thomas Derrick Miller.
Robert Wishart Milne.
Walter William Michael Milton.
Edward Parr Wilmot Morgan, B.Sc. (*Bristol*).
George Alfred Moulton.
Charles Gower Neville.
Henry Cockroft Newton, B.Sc. (
Eric Spencer Norris.
Leonard Douglas Turner Ostic
John Edward Partridge.
Kenneth Ivory Noel Paton.
John Herbert Pean.
John Peel.
Cedric Howard Pendlebury.
David Phimister.
Richard Thomas Poole.
Charles Geoffrey Price.
Ray Leighton Pryce.
Frederick Bernard Raymer.
Alistair James Robertson.
Geoffrey Ernest Robson.
John Runcie.
Henry Dennis Russell.
Endre Schwarcz.
Douglas Andrew Scott.
John Scrimgeour, B.Sc. (*St. Andr*
Nanji Nagsi Shah, B.E. (*Bombay*)
Hari Sinha, B.E. (*Bombay*).
Sudhir Kumar Sinha.
William Edward Haslam Sloan, (*Manchester*).
Geoffrey Snowball.
Harry South.
Harry Arthur Martin Stower, (*Bristol*).
James Sturton, B.Sc. (*Aberdeen*).
Hugh Brown Sutherland.
Fred Hugh Sykes.
Garness Cecil Trower.
Philip Ramssey Turland.
Geoffrey Percy Turner.
John Edward Turner.
Robert Cowan Tweddel.
Edward Julian Upton.
Oliver Joseph Jeparatnam Wats
George Frederick Weaver.
Kenneth Westerby.
Kenneth Charles Westhorp.
Athelstan Whaley, B.A. (*Cantab.*)
John White.
Don Noel Grenville Wickramasin
John Purchase Wilkins.
Louis Wimalaratnam Williams.
Robert Frederic Woodhead.
Wilfred Wright.

he Scrutineers reported that the following had been duly elected as

Members.

NALD HERBERT BLAKE, M.C.
ERT HYDE BUCKLEY.
PAUL COULTHARD DEWHURST.
HENRY COBDEN TURNER.

Associate Members.

McCRAE ADAMS, Stud. Inst. C.E.
ERT ACKROYD ALLATT, M.Sc. (*Leeds*), ud. Inst. C.E.
TER JACK ALLEN, B.Sc. (Eng.) (*ond.*), Stud. Inst. C.E.
SYDNEY ALLWRIGHT, B.Sc. (Eng.) (*ond.*), Stud. Inst C.E.
BERT ST. CLAIR PORTER ANDREWS.
EST BALASINGHAM ANKETELL, B.Sc. (*las.*).
ARMOUR, Stud. Inst. C.E.
DUDLEY BENHAM, B.E. (*New Zea-nd*).
GLAS JAMES BRIGHT, B.Sc. (Eng.) (*ond.*), Stud. Inst. C.E.
TER JACK BROOME.
ARD JOHN BUCKLEY, B.Sc. (Eng.) (*ond.*).
LES WILLIAM BURNETT, B.Sc. (*las.*), Stud. Inst. C.E.
EY BUXTON, B.Eng. (*Sheffield*).
CALWELL, Stud. Inst. C.E.
RY CANNELL, M.Eng. (*Liverpool*), ud. Inst. C.E.
ES CARBERRY, B.Sc. (*Belfast*).
IAM GEORGE CARTER, B.Sc. (*Bristol*).
PH WARD SAMUEL CASEBOURNE, ud. Inst. C.E.
RLES REGINALD RICE CHAPLIN, Stud. st. C.E.
EDMUND LAYCOCK CLEMENTS, B.A. (*antab.*).
HATCH COLES, B.Eng. (*Sheffield*), ud. Inst. C.E.
LIAM DAVID COOKE, B.Sc. (*Edin.*).
GLAS HARLOW COOMBS, B.Sc. (*Lond.*).
CAVE COTTON, Stud. Inst. C.E.
IP BERNARD COX, B.Sc. (*Birming-m*).
CLIVE CROSSLAND-HINCHLIFFE, Sc. Tech. (*Manchester*).
L EDGAR CRUICKSHANK, B.Sc. (*Aber-en*).
WALTER GWYNNE CURTIS, B.Sc. (*ristol*).
ERT WILLIAM DALE, Stud. Inst. C.E.
EST CECIL DE ALWIS, B.Sc. (Eng.) (*ond.*).
BERT ALFRED DEAN, Stud. Inst. C.E.
LIAM ERIC DIGBY, B.Sc. (Eng.) (*ond.*).
LIAM GEORGE DOUCH.
OLD GORDON DOUGLAS, B.Sc. (*Dur-m*).
JOHN GARNET DOWDESWELL, Stud. Inst. C.E.
CHARLES HERBERT DUFF, B.Sc. (Eng.) (*Lond.*).
FRED HORNCASTLE EASTWOOD, B.Sc. (*Manchester*), Stud. Inst. C.E.
JOHN ALEXANDER EDWARDS, B.Eng. (*Liverpool*).
JOHN ELLIS, B.Sc. (*Leeds*).
CHARLES REGINALD FARRELL, B.Sc. (Eng.) (*Lond.*).
FREDERICK FAWCETT.
EDWARD JAMES FAWDRY, B.Sc. (Eng.) (*Lond.*).
GERALD FITZGIBBON, B.A., B.A.I. (*Dubl.*)
WILFRED LESLIE FLETCHER, Stud. Inst. C.E.
ARTHUR JAMES FRANCIS, M.Sc. (*Birming-ham*), Stud. Inst. C.E.
JOHN RUDOLPH FREEMAN, Stud. Inst. C.E.
SHALOM JEHUDA FURER, B.A.Sc. (*Toronto*).
WILLIAM ROBERT GARRETT.
WILLIAM GEORGE NICHOLSON GEDDES, B.Sc. (*Edin.*), Stud. Inst. C.E.
ROBERT LAWRENCE GEE, Stud. Inst. C.E.
HERBERT FREDERICK GOLDSMITH, B.E. (*Sydney*).
KENNETH HALFORD GOODACRE, Stud. Inst. C.E.
JAMES ARCHIBALD GOODSIR.
JOHN GLOVER GRAHAM, B.Sc. (*Glas.*), Stud. Inst. C.E.
GEORGE GRAY, B.Sc. (*Glas.*), Stud. Inst. C.E.
JOHN GRAY.
RICHARD HASLAM GREAVES.
LESLIE REGINALD GREENAWAY, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
DERMOT WILLIAM GREHAN, B.A., B.A.I. (*Dubl.*), Stud. Inst. C.E.
GETHIN GRIFFITHS.
BHABATOSH GUHA, B.E. (*Calcutta*).
NARHAR SAWALARAM GUPCHUP, B.Sc. (*Edin.*), B.E. (*Bombay*).
WILLIAM ALEXANDER GUTHRIE, B.Sc. (*Birmingham*).
BASIL LYNDHURST COLTON HAINES, B.Sc. (*Durham*), Stud. Inst. C.E.
ERIC COLIN HALL, B.E. (*New Zealand*).
REX HAMMOND.
ROBERT JOSEPH HARDING, Stud. Inst. C.E.

Jack Goodman Hawkins.
Charles Leslie Heeler, Stud. Inst. C.E.
Arthur Maurice Hill, Stud. Inst. C.E.
George Fraser Hogg, Stud. Inst. C.E.
Philip Henry Thomas Holloway, B.A. (*Cantab.*).
James Howard Humphreys.
Robert Inglis, Stud. Inst. C.E.
Charles Anthony James Inman, B.E. (*Sydney*).
Harold Kenneth Johnson, B.Sc. Tech. (*Manchester*), Stud. Inst. C.E.
John Kelvin Jones, B.Sc. (*Wales*).
William Butler Kavanagh, B.Sc. (*St. Andrews*), Stud. Inst. C.E.
Laurence Tennant Keiller, B.Sc. (*Edin.*).
Falconer Keir, M.M., B.Sc. (*Edin.*).
James McFarlane Kesson, B.Sc. (*Glas.*), Stud. Inst. C.E.
Richard Stanton Kevill.
Chintaman Hari Khadilkar, B.E. (*Bombay*).
Robert Lacey, Stud. Inst. C.E.
Clifford Douglas Albert Lake, Stud. Inst. C.E.
Robert Arthur Leeming, B.Sc. (Eng.) (*Lond.*).
William James Llewellyn, Stud. Inst. C.E.
Eric Barton Lockett, Stud. Inst. C.E.
Jack Bolland Longbottom, Stud. Inst. C.E.
John Frederick McIllwraith, B.E. (*Sydney*).
John Henry Mahy, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
Edmund Ironside Marsh, B.Sc. (Eng.) (*Lond.*).
James Martin, B.Sc. (*Edin.*), Stud. Inst. C.E.
Richard Mason, B.Sc. (*Edin.*), Stud. Inst. C.E.
Edmond Mathieson, Stud. Inst. C.E.
Marcus Norman Medrington, Stud. Inst. C.E.
Robert Christopher Melville, B.Sc. (*Edin.*), Stud. Inst. C.E.
John Milburn, B.Sc. (*Durham*).
Reginald Alfred Miller, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
James William Milne, Stud. Inst. C.E.
Thomas Mitchell, B.Sc. (*Edin.*), Stud. Inst. C.E.
Alfred Thomas Morris, Stud. Inst. C.E.
Eric Billingham Nash, B.Sc. (*Birmingham*), Stud. Inst C.E.
John Mitchell Nicholson, B.Sc. (*Durham*), Stud. Inst. C.E.
Donald Francis Offord, Stud.Inst.C.E.
Dennis Frank Orchard, B.Sc. (Eng.) (*Lond.*), Stud. In C.E.

Francis Victor Osborne, Stud. C.E.
Archibald Paterson, Stud. Inst.
John Thomas Payne, B.Sc. (*Lond.*), Stud. Inst. C.E.
John Frederick Peck, B.Sc. (*Lond.*).
Arthur Cyril Perera, B.Sc. (*Gla*
Sorabji Merwanji Postwala, (*Bombay*)
Benjamin Preston, B.Sc. (*Manch*
Leslie George Pritchard.
Sheikh Abdur Rahim, B.Sc. (*Lond.*).
Donald David Reid-Thomas, (*Cantab.*).
Philip Reilly.
Robin Edmund Reynolds, B.Sc. (*Lond.*).
Leonard Albert Rhodes.
Raymond Calverley Riley, (*Dubl.*).
Andrew Gordon Robb, B.E. (*New land*).
Hubert Arthur Roberts, Stud. C.E.
John Robinson.
Henry Kenneth Roseveare, (*Cantab.*), Stud. Inst. C.E.
John Couch Adams Roseveare, B.Sc. (Eng.) (*Lond.*), Stud. Inst.
George Mabyn Ross, C.I.E., B.A.I. (*Dubl.*).
John Burgess Rowntree, B.E. *Zealand*).
Laurence Francis Henry Rud Stud. Inst. C.E.
Arthur Basil Salmon.
Chhotalal Hirachand Sanghvi, (*Bombay*).
Ganpatrao Vishwanath Sathe, B.E. (*Bombay*).
James Baguley Schofield, B.Sc. (*G*
Percival Frederic Dreweatt Se B.Sc. (*Manitoba*).
Harry Seddon, B.Sc. (Eng.) (*Lo* Stud. Inst. C.E.
Mohammed Kasim Ghansibhai Sh M.Sc. (Eng.) (*Lond.*).
John Dixon Sharman.
Andrew Sinclair.
Brahma Singh, B.Sc. (*Allahabad*).
William Smart, B.Sc. (*Edin.*), S Inst. C.E.
Cyril Bardell Smith, B.Sc. ((*Lond.*).
Ian Lewis Smith, B.Sc. (*Aberdeen*).
Joseph Duncan Steel, B.Sc. ((*Lond.*).
James Arthur Stephenson, B.Sc. (*ham*), Stud. Inst. C.E.
Edward Sterne, B.Sc. (Eng.) (*Lond*

AN LEONARD STONE, Stud. Inst.
.
CHARLES MIDDLETON TAYLOR.
P STRATFORD TAYLOR, Stud. Inst.
.
RT ALLAN TENNANT, B.E.
tional).
K GEORGE THOMAS, Stud. Inst. C.E.
K DENNIS THOMAS, B.Eng. (*Liver-*
), Stud. Inst. C.E.
ST JAMES TONELLI.
ST RUDOLF TYZACK.
CROSBY VEALE, M.Eng. (*Liverpool*),
d. Inst. C.E.
EDWARD WARDROPPER, M.Sc.
g.) (*Lond.*).
WATTS, B.Sc. (Eng.) (*Lond.*).
K SYDNEY WAYMAN, B.Sc. (Eng.)
nd.).

FREDERICK ARTHUR REGINALD WEBB.
JACK DENIS WEST.
JAMES BLAKE WHITEHEAD, Stud. Inst. C.E.
RICHARD WHITING, Stud. Inst. C.E.
DONALD GEORGE WILLIAMS, B.Sc. (Eng.) (*Lond.*)
JAMES VAUGHAN WILLIAMS, Stud. Inst. C.E.
LOUIS CHELVARUTNAM WILLIAMS, B.E. (*Madras*).
GRAHAM GUY WINGFIELD, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
NORMAN ARTHUR EVANS WOOD, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
MICHAEL PAUL WRIGHT, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.
KENNETH GILCHRIST YOUNG, B.Sc. (Eng.) (*Lond.*), Stud. Inst. C.E.

Associates.

SIMPSON, M.Sc. (*Liverpool*).

JOHN THEODORE HOWARD TURNER, M.Sc. (Eng.) (*Lond.*).

BRITISH-AMERICAN ENGINEERING CONGRES 1939.

The following Paper, dealing with conditions in Great Britain, w have been presented at the British–American Engineering Congress at York in September, 1939, and was therefore primarily prepared reading before American Engineers.

"Activities for the Improvement of the Social and Econo Status of the Members of the Civil Engineering Professio

By Sir Clement Daniel Maggs Hindley, K.C.I.E., M.A., President Inst. C.E.

In order to examine this subject, it is useful to consider generally conditions which, in a democratic country, influence or determine the s and economic status of any profession or calling. It would seem t axiomatic that status depends fundamentally on the technical and et standards maintained. Even with the most rigid protection of la tradition, a profession or calling cannot improve, or even maintain, its st if it does not make itself worthy of public confidence and worthy of pr remuneration by giving efficient and disinterested service ; and the ab to give such service depends on the extent to which the profes maintains its standards, technical and ethical.

It is even possible to argue, with some historical support, that a fession or calling which by artificial means is given a monopoly of cer activities, and is consequently relieved from economic pressure, is liab allow its standards to deteriorate. At this stage, however, it is sufficie recognize that status is dependent on maintenance of high standards.

As secondary influences on status may be noted (*a*) legislativ statutory protection, and (*b*) traditional public recognition and res for the degree-giving or diploma-giving body. The former may consi legal prohibitions against activities of a certain kind being exercised persons not specifically qualified under prescribed standards. Furt there may be legal restrictions on the use of designations or professi appellations except by the acquisition of prescribed qualifications. Las there may be certain privileges granted by law to the members of a cal or profession in return for services which may be demanded by the St Although these forms of protection are generally designed in the inte of the public or the State, rather than of the particular professio calling, they nevertheless may be a powerful factor in protecting

ssion or calling, and consequently in tending to improve the social conomic status of its members.

e influence on status derived from (*b*), traditional public recognition espect for the authority granting diplomas, depends on historical rs which vary considerably in different countries, and is possibly of importance in Great Britain than elsewhere; it should, however, ted that the continued value to the profession of this recognition is y dependent on the standards maintained; this influence is con-ntly to be regarded as secondary in importance to that of the tenance of standards.

ere is a third category of influence, which includes the efforts made by rofession or calling to inform the public of its acquirements and vements, whether these efforts are of an active nature in the form of aganda or rely merely on a tacit appeal by obvious success in vement.

regard to propaganda, it is necessary to observe that in most pro-ns active propaganda undertaken by an individual for his own it is rightly regarded as unethical, and, in fact, it is this self-imposed ction that differentiates a profession fundamentally from other gs. From the ethical standpoint there need be no such restriction e activities of the central authority of the profession, and, in fact, y well feel under some obligation to the public to promulgate in the , or through its own publications, information as to the value of its ssion to the general community, records of advancement in knowledge ractice, and descriptions of its achievements in service to the public.

efore concluding this general review of the conditions which influence ssional status, it may be well to glance at the measures which have adopted effectively, mostly by callings not of a professional nature, prove social and economic status. Amongst these are (*a*) restriction mber of new entrants; (*b*) refusal to collaborate with non-members; llective bargaining in regard to remuneration and conditions of work; *d*) political influence through voting power. These measures will be red to later in relation to the specific case of the civil engineering ssion.

Vith these general considerations in mind, it is now proposed to deal the particular case of the civil engineering profession and its position eat Britain.

t the commencement of the nineteenth century the professions rally recognized as such were limited to the Church, the Services is, the Army and the Navy), and the Law. In the social structure of time, which was based largely on land ownership and pedigree, these callings which "a gentleman" might enter without losing status. were thus sharply differentiated on the one side from crafts which lved manual labour, and on the other side from business which involved ng and selling. Certain other professions were beginning to obtain

recognition as such, although of inferior social status, such as mec education, banking, music, and art. In all these professions the econ status was low. In the first three there were prizes to be obtained carried high remuneration such as bishoprics and other high offices i Church, judgeships and political office for the legal profession, and military and naval rank in the Services; but for the rank and file in professions the social position obtained was often difficult to support to the low level of salaries or fees obtained.

At that time engineering as a profession was unknown in civi although military engineering had long been recognized as a profes activity, and military engineers were sometimes entrusted with the struction of roads and bridges. For some centuries engineering wo public utility such as land drainage, water-supply, and docks and harb had been carried out by men, often of humble origin, who had instin ability in the construction of such works, such as was generally asso more with art than science. Examples may be found in the draining fens by Vermuyden, the supply of water to London by Myddelton, c by Brindley, and at a later date harbours and maritime works by Sme These men conceived the works, designed them broadly, and carried out by direct labour such as the millwright, the blacksmith, the maso quarryman, and gangs of labourers under gangers.

The contractor, as he is known to-day, carrying out the work t design and under the supervision of the engineer, only made his appea in the early part of the nineteenth century. It was, in fact, Thomas Te the first President of The Institution, and regarded by many as the fo of the civil engineering profession, who was largely responsible for dev ing the system of carrying out public works by contract. Many c conditions embodied in modern contracts owe their origin to him.

This separation of the two functions, namely, the function of desig supervision and the function of execution, gave an important stimul the acquisition of scientific and practical knowledge by the engineer had to fit himself to direct the efforts of the contractor. Furth contained the germ of the idea underlying modern professional e namely, that the engineer is remunerated by fees and the contract profits.

The growth of engineering as a profession owed most of its progr the fact that in 1820 a group of young engineers, who had, 2 years be formed a society called The Institution of Civil Engineers, invited Te to become their first President, a position which he occupied for 14 y With the collaboration of others, whose names are remembered honour, Telford succeeded in laying the foundations of the profession in the Royal Charter, which was granted in 1828, can be found pre which throughout the past century have guided the policy and the acti of The Institution.

If at the present time the members regard the provisions of the Ch

ngently binding on them, it is not entirely because they revere
emory of the men who designed it and honour the traditions which
stablished. It is because they cannot but recognize that obedience
precepts enables them to maintain and improve their technical and
l standards, while giving them ample scope for developing activities
le for the ever-advancing social and economic conditions of the
as a whole. It is a remarkable tribute to the foresight and purity
ive of the founders of The Institution that, through all the enormous
pments of the last century, few changes, and those in detail only,
had to be made to the original document, the first Charter of The
ution.

is worthy of note that the cardinal principle of this Charter is that
nstitution is set up for the advancement of mechanical science.
indeed, is the main or sole object with which the body corporate
itled to act, and all other things are subservient to that primary
on. The whole of the resources of The Institution are to be used
is function—it is forbidden to use them for the benefit or profit of any
dual member. It is out of this fundamental principle that the whole
e of The Institution as it is known to-day has been built up. The
il, the governing body, elected by the members, have to see to it that
e is admitted who is not fully qualified to partake in this mission of
cing engineering science, and hence they have laid down standards
attained both in education and practical knowledge by those who are
ted as members, and they regulate the training of students who
to be members. For similar reasons the Council have power to
ibe standards of ethical conduct, and to expel those who offend
st those standards. In pursuance of the main object, the Council
de facilities for interchange of knowledge and experience, by reading
iscussion of Papers, and by publishing to the members and the public
ccounts of such discussions, and, finally, they use the resources of The
ution in the active pursuit of new knowledge by promoting scientific
rch.

regard to technical standards, The Institution has been perhaps the
er of the principle that an engineer cannot be made by book-learning
. Indeed, in the earlier years attachment to the necessity for practical
ng and experience was so great as sometimes to obscure the equally
need of sound scientific education.

elford himself spoke and wrote in forcible terms of the impossibility
aching proficiency without practical experience, but the need for
tion, both general and scientific, became more recognized as the
th of industry produced more and more complex problems to be
d. The advance of pure scientific knowledge throughout the earlier
of the nineteenth century, and the applications of science to industrial
lopment, gave enlightenment about the fundamentals of engineering
ice, and in the second half of the century a start was made in many

schools, colleges, and universities, of teaching engineering science as s ject separate from the pure sciences. In the last decade of the ce engineering courses were already established in some of the univer and it was at this time, in 1896, that The Institution formulated it standards of scientific knowledge by introducing examinations fo admission of students and new members.

These examinations were, from the first, of a standard equal t highest standards aimed at in the universities. They have progres been raised, and by keeping a rigid control of the exemptions perm The Institution has been a powerful factor in maintaining and r engineering educational standards in colleges and universities.

The Institution, however, avoided the error of becoming m a degree-giving or diploma-granting body, like a university, by insisti a period of practical training being added to the attainment of the scribed educational standard before admitting a candidate for electi membership.

The prescribed qualifications, both of education and training, always been tenaciously and jealously administered without fear or fa and it is claimed that this has been a powerful factor, if not indee primary factor, in improving professional status. At the present tim qualifications inherent in corporate membership of The Institutio recognized universally as credentials of the highest order both in tech ability and in professional or ethical standards, and in the opinion of i this provides a status which could not have been reached had the dev of the leaders of the profession to the precepts of the Charter been tenacious or less conscientious.

The significance of the grant of a Royal Charter lies in the fact recognition of the highest authority in Great Britain has been g firstly to the need in the public interest for a body corporate to adva particular object, and secondly to the competence of the body of me whom the Charter is conferred to carry out that object. A Charter is obtained after an exhaustive inquiry has been made into these two c siderations by the Privy Council, on whose advice the Sovereign grant Charter. The exercise of this function is largely removed from pol influence, and once the Charter is granted, the body corporate is left to carry on its duties without interference so long as it complies with terms of the Charter. The penalty for action contrary to those terms less than the forfeiture of the Charter itself.

It was the intention of those who framed the objects to be includ The Institution's Charter, the terms of which were based on the petiti the Council of The Institution to the Crown, that the activities of the I should cover the whole field of engineering science. The terms expli include all such activities, and it has always been maintained that Institution should include members of every branch of the profession. this reason there has been a successive broadening of the qualificat

ed for membership, and the Roll for many years past has included, s civil engineers in the restricted sense, engineers of many other es such as mechanical, electrical, marine and naval, mining, gas, ructural engineering. Although for nearly a century The Institution he only Chartered body of engineers in Great Britain, other more ized bodies of engineers grew up alongside it, and eventually ded in obtaining Charters of their own, as will be seen from the ng list :—

	Established.	Chartered.
e Institution of Civil Engineers	1818	1828
e Institution of Mechanical Engineers	1847	1930
e Institution of Gas Engineers	1863	1929
e Institution of Electrical Engineers (until 1889 known as The Institution of Telegraph Engineers)	1871	1921
e Institute of Marine Engineers	1889	1933
e Institution of Mining Engineers	1889	1915
e Institution of Mining and Metallurgy	1892	1915
e Institution of Automobile Engineers	1906	1938
e Institution of Structural Engineers (formerly the Concrete Institute)	1908	1934

is a matter for argument, now largely of an academic nature, whether ngineering profession would have obtained higher status and more recognition if these schisms in the body of engineers had not taken It may well be that with the rapid proliferation of the science there was need for separate bodies to control standards appropriate to branch, and that the multiplication of societies has stimulated h; but on the other hand there have been many occasions when the sion as a whole would perhaps have been better served if it could have n with an authoritative voice, and efforts of various kinds have been rth in recent years to achieve such a possibility.

has been argued, for instance, that certain other professions who have a unity have been able to exercise more influence on public opinion n Governmental action by reason of such unity, and that thereby have been able indirectly to improve their professional status. The has some attraction, and has been revived on many occasions when osition of the profession has seemed to be in jeopardy, when its s to make its influence felt have not met with apparent success, or economic conditions have resulted in inadequate remuneration for nk and file.

fforts to secure unity have been many and various. The possibility eration has been explored, only to be rejected, primarily because of the sity of standards, and secondly because of the natural loyalty of the bers of different branches to the traditions and interests set up by their al Institutions. The most notable of these efforts was perhaps the g up of the Engineering Joint Council soon after the war of 1914–18, g as its founder members the Institutions of Civil, Mechanical, and

Electrical Engineers, and the Institution of Naval Architects. Thi has been a useful medium for debating matters of common interest b the Institutions. The Founder Institutions were, however, reluct give it any executive powers, because they could not consistently wit Charter obligations delegate power to deal with matters of polic composite body. Consequently the Engineering Joint Council h found it possible to originate new developments, still less to assu function of speaking on behalf of the profession as a whole.

A more recent development of the idea of co-operation be different Institutions has been the exploration of common interest lateral direction, and here the Engineering Joint Council has b considerable utility. For instance, it has been the medium for ca out the desire of the Institutions to establish a common stand entrance to the profession by students. From this year eight Instit have co-operated in setting up a Joint Engineering Examination I to control the examinations for a common preliminary examinatio test of general education.

In other directions this idea of lateral lines of co-operation has developed. The Research Committee of The Institution has set up committees for research into special subjects, those committees taining representatives of other Institutions. It has also partici in a similar way in research work initiated by other Institution further example of co-operation has been the establishment in 1937 Engineering Public Relations Committee, on which fourteen Institu are represented and which has been responsible for a widespread expa of the means of giving the public and the Press information abou work of engineers in furthering engineering science.

All these co-operative efforts have undoubtedly had an influen the status achieved by the profession, and while it is difficult to env any closer corporate union between the various branches, it is clear advances in co-operation must tend towards a better appreciation b public of the value to the community of the work of engineers.

It is necessary now to refer briefly to the standards of ethical or fessional conduct laid down by The Institution for its members. I earlier form the rules of professional conduct were designed primari determine the relations between a professional engineer acting as a sultant, and his client. The principles underlying these rules were tha engineer was to act in a fiduciary capacity towards his client, was to ac fees as his only remuneration, was to keep clear of any entanglements as might influence, or be held to influence, his professional judgment, was not to solicit professional practice. For many years these were only rules laid down for the guidance of engineers. They were in r respects inappropriate to the work which many members of The Instit found available to them. They had no direct application to contrac to manufacturers, or to many in salaried appointments under p

ities or commercial firms. For instance, the prohibition of adver- could not be properly applied to contractors or manufacturers, ayment by fees only was inappropriate to many other activities d in by members of The Institution properly qualified by all the bed standards. It was obviously detrimental to retain a code could not be universally enforced. It was equally detrimental to ers as a whole to attempt to restrict membership of The Institution se only who worked in a consultative capacity. The code has ingly been revised and extended in recent years, and is thought to e a reasonable guide to conduct for engineers in whatever capacity nay be serving. The procedure for dealing with offences against rules has been carefully drawn up with legal advice, and it is hardly ary to say that it is very seldom indeed that the Council have had to is procedure into action.

has been said that from time to time there have been movements to about action in the direction of influencing public opinion or the nment in the interests of the profession, and in improving its status. ouncil have had to make decisions as to whether or not such action fall within the terms of the Charter; whether, that is to say, the could be justified as being directed to the advancement of mechanical e, or whether it had a primary motive of benefiting the members of the sion. The choice has not always been easy, but the consistent view of ouncil in maintaining the advancement of mechanical science as the object of The Institution was greatly reinforced by a judgment in the of Appeal in a case which arose out of a claim by the Inland Revenue tment that the funds of The Institution were liable to income tax. ourt's interpretation of the Charter was that The Institution's main was a charitable one within the law relating to charities, and that e tax could not therefore be collected. In giving that judgment, er, the Court stated that such advantages as members might obtain h their membership were incidental to such membership, and that uently any activity of The Institution which had for its main the advancement of mechanical science, even though the members y gained in status or prestige, was not contrary to the purpose of arter.

is recent interpretation of the Charter by the highest legal authority rnished a criterion by which it is possible to judge whether or not any sed activity is within the terms of the Charter. If this criterion be d to any of the activities referred to on p. 185, it will be seen at once n the main they are outside the scope of the Charter, and for this the Council have studiously avoided any action on these lines.

has been argued in some quarters that in the interests of the pro- n the Council should seek to have the Charter amended in order to t activities of this kind. The Council have, however, considered elves to be in some sense trustees of the intentions of the original

founders, and when this question came up in 1934 they decided any departure from the principles laid down for their guidance founders, for the reasons which have been explained on pp. 186–18 the same time the Council decided to pursue as far as seemed practica improvement of the means of giving to the public and the Press infor as to the work of the profession, advances made in engineering scien descriptions of works carried out. The Minutes of Proceedings Institution, formerly published twice yearly, were replaced by a published eight times per year, which includes Papers read and dis other selected Papers on engineering works, and reports on rese progress. Collaboration with other engineering bodies was also ob in the formation of the Engineering Public Relations Committee, r to earlier, which has instituted lectures, collected cinematograph-fil provided an information-service for the Press. It is believed that b means the public at large will in time become more accustomed to an interest in engineering matters, and, incidentally, will have their at drawn to the value of engineering to the community.

This is a line of action which needs time for its development. I in fact, at a gradual process of education of the public to make them of the continual process of development of engineering science and co of the benefits they derive in their everyday life from the work of eng The profession is well served by the technical Press, and there is no media of information to those who are technically interested penetration of engineering into the non-technical Press is, howe process which can only come about by consistent effort, by making av information in a popular form and by giving assistance wh engineering subjects become of topical interest.

There are, of course, many who are not satisfied with this lon policy of publicity, and who urge the need of some more obvio striking policy to put the engineering profession in a position where receive more recognition by the public, and by the Government an public authorities. This desire has recently manifested itself i directions. The first of these is that, with the recognition tha Institution and other engineering bodies are precluded from taking on the lines generally called "Trade Union" lines, such as are refer on p. 185, there has come into being a body known as the "Eng Guild," promoted by a group of younger engineers. It is too early history to estimate what effect or what influence such a body may but it is obvious that it must take a considerable time to devel activities to a point where it can have any specific effect on status. second development is a movement, which has secured some su for the registration of engineers by Act of Parliament, on the lines re adopted by the architectural profession. This is a matter which is to give rise to considerable controversy. The subject has been exa by a committee of the Engineering Public Relations Committee, wh

ied the facts and the arguments on both sides in a report which is at t receiving the consideration of the principal engineering bodies. , therefore, the question is at present *sub judice* so far as official h is concerned, it may perhaps be permissible to state certain nental considerations. The registration of engineers, if it follows es adopted in other countries and the lines of the recent Architects ration Act in Great Britain, postulates the setting up of a Council or charged with the duty of registering those engineers who fulfil standards of qualification laid down either by the Act or by the itself.

hilst the practical difficulties which such a change presents have been me in the United States and Canada, where registration has been in or many years, there are conditions prevailing in Great Britain which involve more serious difficulties in carrying through the necessary tion. Not the least of these difficulties is the selection of a suitable ation for the person registered. The plain designation "engineer" ady used by many who have no claim to professional status, such as, stance, the members of the various engineering trades unions. It be out of the question to secure the passage through Parliament of which would deprive thousands of men of the right to use the name neer", which they have possessed for many years. Similar difficulties themselves to almost any other simple designation which can be d. It is not suggested that this seemingly trifling difficulty would registration impossible, but this difficulty in itself covers a much wider of difficulties of defining in a Statute the classes of persons to be e for registration, remembering that such definitions, however they be drafted initially, would emerge from Parliament in a form d by compromise between members of the legislature of widely ng political views.

owever attractive it may be to persons at present possessing no nized qualification to be admitted to a register which would secure recognition of their right to be called engineers, it is difficult to see would be gained by those whose position is already secured by the sion of the certificate of membership of a Chartered Institution, as The Institution of Civil Engineers, or other body which has been ed a Charter. To exchange the right to be called a chartered eer for the right to be called a registered engineer would not in be a guarantee of improved status. It must also be remembered that, ver carefully the Act might be designed in the matter of prescribing ards of admission to the register, there could be no guarantee that such ards would not be lowered by the Board or Council, or by subsequent ation, and no guarantee that considerations other than those of ical qualification would not in time influence the Board or Council in tting persons to the register. It seems obvious that the power and to prescribe standards would pass from the present Institutions to the

proposed Registration Board or Council, and that the Institutions w
time lose the position they have acquired so laboriously and caref
many years of leadership. The Author is of opinion that no surer
could be found of jeopardizing the social and economic status wh
been achieved by the Institutions, who are guided by their Cl
than to acquiesce in the handing over of their standard-making fu
to a statutory body.

In the Author's view, the activities which have been descr
namely, the maintenance and improvement of the standards of te
qualifications, and a rigid adherence to the prescribed standards
fessional conduct, coupled with co-operation with other engineering
in the furtherance of these standards—are the activities best cal
to improve the social and economic status of the engineer. Any dep
from the principles and precepts of the Charter, in the shape of ac
directed specifically to the improvement of the status of individuals,
be likely to react unfavourably on the profession, because inevitab
purity of motive of the governing body would become suspect a
usefulness would be hampered. So long as it can be said that The I
tion is devoting all its efforts to improving the technical standards
members and to upholding ethical principles, it will continue to
high position in the community, in which its members will share. I
well be that the environment in which British engineers work is so di
from that in other countries that different activities are necessary,
any rate the experience of British engineers may be of use in other cou

Paper No. 5229.

"The Haifa–Baghdad Road."

y LIEUTENANT-COLONEL RAWDON BRIGGS, D.S.O., M.C., R.E.

(*Ordered by the Council to be published with written discussion.*)[1]

TABLE OF CONTENTS.

INTRODUCTION.

work described in this Paper is not yet completed and the Author up charge of the work at very short notice. It should, therefore, ated that some of the facts and figures submitted are subject to mation. It is hoped, however, that the description of the processes and difficulties to be overcome, and the description of the organization ed for a work of such magnitude, carried out by military engineers in art of the desert, may be of interest to civil engineers.

e Author, assisted by Captain A. M. Hamilton, B.E., Assoc. M. C.E., who had constructed the Rowanduz road through Kurdistan, took the task of preparing an approximate estimate for that portion Haifa–Baghdad road from Jisr-el-Majami on the river Jordan to the jordan–Iraq frontier, as an agency work for the Colonial Office. The was to be :—

1) passable throughout its length in good weather, and workable with the minimum of delay in wet weather;

2) suitable for a maximum axle load of 8 tons;

Correspondence on this Paper can be accepted until the 15th May, 1940, and will blished in the Institution Journal for October, 1940.—SEC. INST. C.E.

(3) built by direct labour;
(4) completed in 2 years;
(5) designed on the basis of a total cost of £230,000, assuming t
work would be necessary on the firm portion of the deser

HISTORICAL.

Since the Great War (1914–18) several railway surveys have been over the route, but costs and government retrenchment have caus abandonment of these schemes.

In 1923, the Australian brothers Nairn, two ex-service men, ma crossing of this desert possible for travellers and freight by run regular convoy service from Baghdad via Rutbah, thence through to Damascus. It is not now liable to attack by tribesmen, but it is to stoppages of a week in wet weather, when the desert becomes a mud and water, and the journey still remains adventuresome.

In 1932, the Iraq Petroleum Company laid a pipe to carry oil fro wells at Kirkuk to Haifa, and laid a duplicate line to Tripoli in The Haifa pipe-line follows the most direct route through British man territory from Rutbah to Haifa, and proceeds straight across this, irr tive of grade or terrain. They cleared a track wide enough for th and for stores-carrying vehicles travelling parallel to the pipe, which described later. Without this track and the tube-wells sunk by the pany along the route this road could not have been surveyed in the nor could construction have proceeded at the pace it did, as only one head could have been worked on owing to the impossibility of supp

THE GEOGRAPHY OF THE ROUTE.

No accurate maps exist of Transjordan. The distance from to Baghdad is approximately 960 kilometres (600 miles).

Haifa–Nazareth–Tyberias–Jisr-el-Majami.

A first-class asphalt macadam road connects these places.

Jisr-el-Majami–Irbid (38 *kilometres*).

The Public Works Department were gradually improving this r the extent of their limited financial resources. The road runs th inhabited country, and rises from 183 metres (600 feet) below sea-le the Jordan to 762 metres (2,500 feet) above at Irbid; it had a four- water-bound macadam surface on 20 centimetres of soling over 24 metres of its length. The unsoled portions were often impassable i weather. The alignment was good, with maximum grades of about 1 but it had many hairpin bends and long side-cuts in rock up the si precipitous *wadis*. The Transjordan Public Works Department agr

ete this portion of the road as a charge to the Colonial Office, and the s being widened with a 5-metres surface of full grout of "Colas" on ntimetres of hand-packed soling on a 7-metre formation, fully bridged ulverted throughout. This portion will not be further referred to in aper.

-Lava Belt (66 *kilometres*).

he pipe-line runs along the side of a range of hills for the first 30 kilo-s, and crosses many valleys, *wadis*, and small steep ridges of lime-. It then crosses a range of hills and is altogether a most unsuitable on for a road. After much cross-country travelling in rough going, d location was found about 5 kilometres north of the pipe-line. It s over good agricultural land, consisting of cotton soil and red clay for lometres, then it runs over loamy clay at the bottom of foot-hills with rous limestone outcrops; it then joins a wide valley at 15 kilometres. it reaches the desert and the route crosses the range of limestone hills a low pass. Instead of a multiplicity of small *wadis*, five large *wadis* o be crossed, and the final grades will not exceed 1 in 20. The Hedjis vay is crossed at a point 42 kilometres from Irbid at Mafraq, where the again meets the pipe-line. The Hedjis Railway is a single line of ow gauge, connecting Damascus and Haifa with Transjordan. At aq is the Iraq Petroleum Company's stores railhead, only a skeleton hat it was in the days of pipe construction, although a good tube-well, lectric-light plant, railway sidings, and a small stores-forwarding staff in. From 5 kilometres west of Mafraq to the lava belt, 14 kilometres is a flat hard desert, passable in all weathers for a limited number of cles. From Irbid to Rutbah in Iraq no water exists, except for such as have been drilled by the Iraq Petroleum Company, until the river hrates is approached at Ramadi.

Lava Belt.

This belt stretches for 170 kilometres and is one of the most desolate forbidding areas on the surface of the earth. It is not flat, but is en up by gullies, undulations, and extinct volcanoes. It is closely red with black basalt rocks piled in confusion, single rocks up to several in diameter lying on the surface; these occur to a depth of about feet. The interstices between the rocks are filled with lava ash. *wadis* run in flood after heavy rain, and the larger ones that flow from Jebel Druse in Syria flow also when the snow melts. The Iraq Petro-n Company cleared a track through this lava, and soled it over a width metres with lava stones, binding the surface with clay and lava ash. track is very rough, and is closed to traffic in wet weather. In con-cting this road little attention was given to grades and it was just laid r the natural ground-level, but it made communication and stores-

carriage possible. In the middle of the lava is H.5 pumping station
Iraq Petroleum Company. No spare water is available here for road
however, and no water is available for a further 25 kilometres; a
distance, 120 kilometres from Mafraq, there is a deep well. A n
spring exists at Azraq, 45 kilometres south of the road, equipped
pumps and an old pipe-line to H.5 pumping station; this will be
ditioned to fill the gap. The highest point on the road is in the mid
the lava, and is approximately 915 kilometres (3,000 feet) above sea-

Lava Belt: Transjordan–Iraq Frontier (90 *kilometres*).

This section runs over a slightly undulating desert of alluvia
underlaid with limestone, and the surface is covered with a layer of
One large deep *wadi* crosses the road, but at many places water cross
desert in wide flat shallow flows, causing no erosion to the surface.
rain this desert becomes a sea of mud and water, and vehicles si
their axles. The annual rainfall is, however, only about 5 inche
stoppages rarely exceed 1 week.

It will be noted that over the whole of this desert no sand exis
clean gravel only exists in some of the *wadi* beds.

Climate.

In summer the temperature rises to 105° F. during the day a
pumping station, and to 100° F. at Mafraq; in winter the temper
reaches 70° F. on a bright day, but it can be very cold at times, 15° o
being sometimes registered at night. There is usually a difference
between day and night temperatures in both summer and winter. V
dust storms are common. The climate can be delightful on a sunny
winter, whilst in spring the desert is covered with grass and flowers.

The average annual rainfall, east of the Hedjis Railway, is
5 inches, whilst west of the railway it is about 12 inches. East of th
way, 5 inches may fall in one place in one day, whilst another place may
little or no rain during the year.

The Estimate and Specifications.

Details of the estimate are too long and involved to describe in f
this Paper, and the processes recommended will be described later
the heading of "The Work." Consideration is given first to the vo
of traffic and the loads. The Iraq Petroleum Company run cross-co
vehicles of 60 tons capacity (on multiple axles with axle-loads of 9 ton
tire-pressures ranging up to 80 lb. per square inch) from Iraq to Ma
commercial lorries from Baghdad with similar axle-loads run over the
to Haifa. Since it was not practical to limit speeds on such a desolate r

s recommended that the surface and formation should be capable of ng all loads on pneumatic tires with pressures not exceeding 80 lb. uare inch, such surface to be continuous over the whole route. Cul- were to take British Standard trainloads. Bridges were to be of the steel-span type as standardized by the Crown Agents for the Colonies, vere to be suitable for strengthening later if required. The heavy es of the Iraq Petroleum Company were to run over the old causeways vere not to use the bridges.

considerable time was spent studying processes, costs, and output of r in Palestine, Egypt, Transjordan, and Iraq, and detailed costs for arious processes recommended were worked out. No detailed survey ttempted, as the time and staff given for the estimate did not allow of Costs of typical sections were, however, worked out in detail. It ecided to recommend that the section from the lava belt to the frontier d be done by contract, as the British firm of Murdoch and Brooks in dad had the plant and trained operators for the type of construction mended, and their prices appeared reasonable. No other firm in the East had the necessary plant. The remainder of the work was to be by direct labour.

detailed plan for organizing and carrying out the work was submitted, her with detailed lists of the staff, plant, tools, petrol, oil, lubricants, ge, etc., which would be required.

e following is a summary of the estimate, excluding agency charges ver overheads :—

	£
1. Cost of road construction	428,430
2. Cost of salaries of subordinate staff	41,210
3. Cost of accommodation	3,000
4. Cost of medical service	4,760
5. Cost of workshops, and transport for staff and its maintenance	10,000
6. Purchase of land	2,000
7. Cost of telephone	1,000
	490,400
5 per cent. contingencies	24,500
Total	£514,900

Depreciation of tools and plant: two-thirds of the value on the work (included in item (1)). (The remaining one-third was to be recovered on disposal.)

he estimate was completed by the middle of October 1937. The d from November 1937 to May 1938 was spent awaiting a decision as hether or not the work would receive sanction. During this time fications were drawn up by the Author for the plant required, for a act for raising and consolidating the earth formation, and mixing, g, and consolidating the surface on the 90-kilometre section of the road

from the end of the lava belt to the Iraq frontier (the work to be d[...] machinery), and for a contract for the hire of tractors, graders, scr[...] and other American-type road plant, for direct employment on [...] sections of the work. Opportunity was taken to get into touch [...] various makers of the types of plant required. Tenders were [...] for, so that as soon as financial sanction was given there should be no [...] in placing the orders. Provisional sanction was given for a staff, an[...] personnel were selected. Sanction was actually given early in [...] Contracts for plant and work were signed and placed, and the ad[...] party arrived in Palestine on the 24th May, 1938.

The Plant, Machinery, and Transport.

The plant used is of particular interest to military engineers becau[...] its variety, portability, and efficiency for this type of work. Owing [...] difficulty of maintaining a large labour force in the desert, machiner[...] used where possible in preference to hand labour. In wartime a [...] labour force on a road is most vulnerable. These mechanical metho[...] road-making attracted considerable interest from engineers in the [...] East, and it was the Author's experience that in Transjordan, wh[...] labourer costs 3*s*. for a 10-hour day, including the cost of his wate[...] accommodation, a considerable economy resulted in the use of machi[...] The saving in some cases was as much as 50 per cent. A brief descri[...] of the plant is given in Appendix I (p. 214).

The Work.

The immediate problems facing the advance party in May [...] were :—

(1) The setting up of a headquarters office and a stores-purchas[...] forwarding department in Haifa.

(2) The construction of a base at the railhead at Mafraq on the H[...] Railway in Transjordan.

(3) Getting the contractor to commence work on the constructi[...] the formation between the lava belt and the Iraq fronti[...] the 25th June, the date on which he was ordered to asse[...] his plant and material.

(4) Keeping the contractor supplied with food and water, oils, l[...] cants, and all such necessary materials.

An office was hired in Haifa and placed in charge of the assistant t[...] Commander (R.E.), an R.E. Captain, who had under him a stores br[...] with a warrant officer in charge of stores, assisted by three locally-eng[...] clerks and one typist. All stores were kept on ledgers in Haifa, and t[...]

y cards when issued to the store at the base at Mafraq, and on ories when issued to any section of the work. The Assistant ander (R.E.) had a clerical branch which dealt with :—

) general correspondence ;
) the construction account ;
) the recruiting of skilled trades from outside Transjordan.

aff consisted of two engineer clerks (Royal Engineers), one draughts- nd one typist (engaged locally).
the same office was the Paymaster, a major in the Royal Army Pay assisted by one sergeant (R.A.P.C.), and two locally-engaged clerks. aymaster paid all labour personally during the first week of each , and prepared and checked all pay-sheets ; on behalf of the C.R.E. ried out an audit of all expenditure, pay-sheets, petrol, oil, and stores ts, and paid all bills. He also acted as an adviser to the C.R.E. on y and financial matters. He had under him, attached to the staff h of the two executive engineers on the road, a locally-engaged pay-

e Iraq Petroleum Company, Ltd., had a stores-forwarding depot at q on the Hedjis Railway, with two railway sidings, which was used the construction of the pipe-line, and which was unused and dis- ed except for a small store, a well, and a lighting plant. This Com- made a great contribution to the ease of starting up the work by g half of their compound and one siding, also 12,000 gallons of water kilowatts of electricity, at the disposal of the War Department. .R.E. was lucky to find that the workshop and living huts of the ordnance workshops at Haifa were, on his arrival, up for disposal by , but as the tenders had not been accepted he was allowed to pur- these at the price of the highest tender, and so obtained, for £100, iving and office huts of corrugated iron lined with three-ply wood, 30 feet by 20 feet, together with two workshop sheds each 80 feet by t. These were dismantled and sent by road and rail to Mafraq to the base camp there. The dismantling and re-erection were carried y the Arab contractor of the Royal Engineer Services at Haifa at his running contract rate. From these an officers' mess and quarters, s.' mess and quarters, native staff block, office block, stores blocks, and hop bays were made. Additional native quarters and stores were of mud-brick and corrugated iron.
was planned to divide the work into two sectors (Fig. 1, Plate 1). e Mafraq sector was to stretch from Jisr-el-Majami to H.5 pumping n, with headquarters at Mafraq, and the H.4 sector was to stretch H.5 to the Iraq–Transjordan frontier, with headquarters at H.4, under an executive engineer. Work was to be concentrated on the nds, where the present tracks were always liable to stoppage in In the autumn of 1939 both sections were to work towards H.5

with headquarters at H.5, and the road was to be completed by t
of the summer of 1940.

An Englishman, who had previously held various positions in Pa
and Transjordan, was engaged as officer-in-charge at the base at M
his duties comprised :—

(*a*) recruiting local labour;
(*b*) reception and distribution of stores, fuel, and food-supply
work;
(*c*) supervision and organization of transport;
(*d*) supervision of plant erection, and of repair workshops fo
and transport.

On the 26th June four 1-ton trucks and four utility cars arrive
were loaded with kit, tentage, etc. The nucleus staffs detailed
departed for Transjordan (the Mafraq party arrived the same da
the H.4 party arrived at H.4, the day after) :—

Mafraq : Deputy-commander, Royal Engineers, Mafraq.
One Royal Engineer N.C.O., engineer clerk.
One Royal Engineer N.C.O., surveyor.
Officer-in-charge of the base.
One ex-soldier, head storekeeper.

H.4 : Deputy-commander, Royal Engineers.
Two Royal Engineers, N.C.O., surveyors.
One ex-soldier, head clerk.

For political reasons it was not possible to employ Jews in Transj
and the Transjordan Government were very averse to the employm
any except unobtainable trades from outside Transjordan; fro
modest beginning, in the course of 4 months, an organization empl
directly, two thousand labourers, and utilizing and operating pla
transport to the value of roughly £80,000, was in operation. The ma
of the operators and labourers were unaccustomed to machinery an
work.

The contractors were prompt in assembling their plant. They
two elevating graders, with 42-inch belts, and a 66-blade grader, by
caterpillar tractors across the desert, 300 miles from Mosul, and s
raising the earth formation 8 metres wide and ½ metre above the
surface on a straight run of 90 kilometres.

Organization.

The base camp at Mafraq.

Living quarters for superior staff and artificers replaced tents
base; workshops, stores, and offices were soon erected with wate
electric light laid on. Contracts were placed locally for black-hair be

for labourers, twenty-five to a tent at a capital cost of £1 per head. bile workshop was purchased containing a generating set from which perated a 6-inch lathe, a drilling machine, a valve-grinding machine, press. There was also a very complete outfit of special tools for ng, maintaining, and testing motor vehicles.

e cost of the work included the hiring of a native police force from esert Legion. This consisted of a motor patrol of one sergeant and *undies*, to work at the Mafraq end, and a camel patrol of four for the d. These men proved invaluable in keeping the peace in the many that occurred, and prevented any serious bloodshed. In addition, ngineer enlisted his own force of armed watchmen, mostly Bedouins d families who had influence with the tribes. They were well in the native fashion. Each labour camp had one or more of these in guards in the proportion of about one to each seventy labourers. men also acted as a secret service to forestall strikes and trouble.

al.

medical officer with a staff of medical dressers, one dresser to each camp, was employed under the supervision of the Transjordan al Service. Four-bedded wards were built at each of H.4 pumping n and Mafraq. All labourers were medically examined, vaccinated, noculated against typhoid and cholera.

iting and pay.

prevent crowds of labourers assembling at Mafraq on the chance of g work, and waiting there with no means of subsistence, arrangements made for headmen of tribes and villages to send men as required. was unsatisfactory, as a body of Arabs from one village or tribe, when ed together, are always conspiring and striking, and will not work t under their own leader, who is more interested in seeing that a um of work is done by his party than he is in his employer's interest. the main body of workers were in constant employment, resort was made to the old system of engaging individual applicants and ing up the gangs.

pon engagement, and after medical inspection, each man was given a disk with a number on it in Arabic and English, and he was registered. ame, number, and rate of pay were entered on his gang's monthly sheet and on the register. A timekeeper, usually a young Arab just chool, with a knowledge of English, was employed on each gang of een 25 and 50 men. On joining work in the morning a line was put in pace for the day opposite a man's name, and the line was made into a at the completion of work. At the end of the month the time sheets

were consolidated on to the wages check list. The totals of pay telephoned to Haifa, and the paymaster flew with the cash to Maf R.A.F. plane, and was escorted by the Police Patrol throughout the Pay took 6 days to complete. On receiving his pay the labourer h in his disk as proof of payment, and he was handed a new disk of di shape for use in the next month. In the following month the o disk was again brought into use.

Communication by telephone.

A private telephone system was laid throughout the length of th and to the Haifa office, and was operated by the road staff. At H connected to the military and civil exchanges. The wire ran on a arm of the Iraq Petroleum Company's telephone, but was freq melted when the pipe-line was punctured and fired by Arab bands. Mafraq office was also connected to the Transjordan telephone syst it was seldom possible to hear speech from Palestine although th telephone-service messages were relaid by R.A.F. wireless from Amm

Communication by rail.

Trains ran 3 days a week from Haifa to Mafraq, but, owi shortage of rolling stock and the steep grades, heavily loaded trucks often left at the bottom of the grade, and sometimes took as long as a to arrive.

Food.

Inquiry was made from various contractors with a view to pla contract for the supply and distribution of food to labourers, an question of the scale of rations was taken up with the Transj authorities. The Transjordan Government, however, were expect insist on a luxury scale that was far in excess of any with which the la ing classes would normally provide themselves, and they would not a contractor outside Transjordan to undertake supply. No contr existed in Transjordan who could be relied upon to carry out a contr this magnitude. It was therefore decided to exploit local initiativ give encouragement to smaller shopkeepers to open canteens in the l camps. It was necessary to ensure, however, that during the wet se no shortage of staple food should occur in any isolated camp. West lava belt, where communication with villages could be obtained b labourers, there was an ample supply at reasonable cost and shopke opened canteens in Mafraq and in the camps. Camels and donkeys bring food and a gang would send a representative to do their shopp some village.

In the lava belt and east of it prices soared, and it was difficult t

a merchant to undertake the business. A big merchant of Amman owever, persuaded on the conditions that :—

) the government transported all his supplies free to his shops from Mafraq ;
) he sold his goods at prices ruling in the settled districts, his prices to be subject to the approval of the C.R.E. ;
) he would be given a monopoly of shops and canteens in the labour camps, although labourers would not be prevented from bringing in outside supplies ;
) he should keep 7 days' reserve of certain staple items in each camp, and 10 days' reserve in store at Mafraq.

ove arrangement worked satisfactorily.

ops and maintenance.

R.E. staff sergeant, military mechanist, was placed in charge of workat Mafraq. He had under him an Arab plant foreman with diesel ence for erection and repair of plant, and an Arab foreman for repair aintenance of motor transport. The transport was running 10 a day on the work, and each vehicle was given a thorough weekly ion in the shops, and was greased, oiled, and looked over daily by ht shift. Each vehicle had a log book in which everything done was d, and a record of oil, tires, and petrol issues were kept ; a 100 per heck was made each month against petrol store-issue books, and trol consumption of each vehicle was worked out.

e acquisition of spare parts was a big problem. Both General , Ltd., and the Caterpillar Tractor Company supplied stocks of spares stores at Mafraq, and agreed to take back all unused spares on teron of the work at cost price. With British firms it was necessary chase stocks of the spares required, involving a large capital outlay. robability was that many parts would be unused. When the ected failure occurred, a delay of from 3 to 4 months was occasioned ing the spares from Great Britain. In these instances parts could be manufactured locally in Palestine or in the shops, but this was more expensive and material or workmanship were inferior.

transport and plant on the Mafraq sector of the road work relied on fraq base for repair and maintenance.

H.4 a similar arrangement was made for maintenance and minor , and a workshop was built there. Major repairs were sent to the orkshop at Mafraq. Each engineer had a foreman mechanic to ise the running maintenance of his plant and machinery on the

ort and distribution of stores.

nding the arrival of three Thornycroft 15-ton flats a local contract ade for the supply of 4-, 5-, and 6-ton trucks. After the arrival of

the Thornycrofts they ran every 3 days to H.4 with fuel, stores plant, food, etc. The journey took from 8 to 10 hours for the 2 metres. These vehicles were able to convey the heaviest machin plant employed on the work with the exception of the R.D.8 t Between trips to H.4 these vehicles made local journeys with sup the Mafraq sector.

The light trucks, cars, and water-tankers were distributed to sec the work as required by the C.R.E. During peak periods extra truc hired under contract.

Bitumen supply.

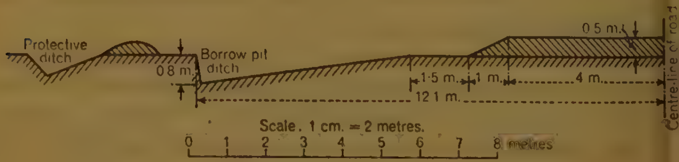
The Shell Company of Egypt, the contractors for the supply of bi received their bitumen by rail in bulk at Mafraq, and transferre storage tanks at their siding. It was then re-heated and delivered War Department's 2,000-gallon Thornycroft road-tankers or into dr required.

Construction.

From east of the lava belt to the Transjordan–Iraq frontier.

In the previous year the Author had visited the R.A.F. cantonm Habbaniya, near Baghdad, where, with a similar soil and an even scarcity of stone, roads had been successfully constructed and had heavy traffic for 4 years without any noticeable trouble. The formation had been raised ½ metre above water-level, and a gravel-and-bitumen pre-mix surface had been laid directly on to the formation. Trouble had occurred only when the roadside drain w close to the edge of the formation; water then penetrated under th It was therefore decided to construct that type of road on this sec the work. The specification to which the contractors were to adh constructing this section of the road, is detailed in Appendix II (p *Fig. 2* shows the main features of the road section.

Fig. 2.



Section of Road.

The elevating graders started work early in July, and had raise over 100 kilometres of the formation by the 1st January 1939 (inc 10 kilometres in the Mafraq sector). The makers claim that the out

ch-belt elevating grader ranges from 225 cubic metres per hour in
nditions to 450 cubic metres per hour in good conditions. In the
hs during which these two machines were employed they elevated
imately 450,000 cubic metres, an average of 1,250 cubic metres per
625 cubic metres per machine per day. The ground, to all outward
ances, seemed ideal for the operation, but over about 30 per cent. of
tance a limestone strata, varying from rotted stone to hard lime-
was struck by the plough. The surface of the desert was also
l with a thin layer of flints up to about 2-inch gauge on the limestone
s. A tractor-drawn rooter had to be employed to break up the
fore elevating it. The rock and flints caused a lot of wear and tear
machines, especially the elevator belts. The machines had a rough
e across the desert from Iraq to the site, causing wheels to collapse,
consequence it was very seldom that both machines were in working
t the same time; sometimes both were out of order. These various
s were not foreseen, and delays were caused in waiting for spares
Baghdad and the United States. The contractor, when possible,
 up to 20 hours per day, and is to be commended for his perseverance
such difficulties of ground and climate. The Author cannot think
 other machinery or any other means of doing the work, either so
y, or at such an economic rate, under the conditions.

npaction of this bank was carried out by blading each layer of soil
 was cast on by the elevating grader and it was afterwards levelled
le where necessary by a 12-cubic-yard carry-all scraper, and it was
d with a slight crown by auto-patrol. At every 400–600 metres the
 pit was filled to allow traffic to enter, to lead on stone later, and to
und during mixing operations. This fill was placed below a culvert
wn grade or on top of a rise.

verts were required on an average of two to three per kilometre,
nsisted of 15-inch reinforced-concrete pipes cast at the nearest water
aid; at each culvert two or three pipes were laid together between
ry headwalls. A number of concrete causeways, with rough masonry
ent-drop walls and with slopes of 1 in 40, were constructed with
ength to allow a maximum depth of 1 foot of water across the road
 flood.

ly one major *wadi* existed in this sector, and it was crossed by six
t spans of single-line heavy-type bridge, built of steel troughing,
standards laid down by the Crown Agents for the Colonies. Piers
utments were of concrete faced with masonry.

ffic was encouraged to use the formation to assist consolidation,
was planned that the winter's rain would sufficiently consolidate the
o allow surfacing to be started in the early summer of 1939. The
l on this sector in the following winter did not, however, exceed
es, and this fell before the section east of H.4 had been completed,
as decided to surface only from the lava to H.4 in 1939.

A protective ditch and bank were made by one cut of a No. 66 grader on the uphill side of the borrow pit, and about 10 metres to lead water to the culverts and causeways, and to protect the pit and edge of the formation from erosion that might be caused by a siderable flow of water in the borrow pit. The borrow pit thus on away rain which fell on the road surface.

The engineer at H.4 spent July sinking trial pits over the desert for stone. It was very difficult to know the quantity of stone that be procurable, as an outcrop was caused by an upward bend in the and a good strata would often disappear in the earth again befo considerable quantity of stone was excavated. Many outcrops wer to be of poor quality or a thin layer only. New quarry sites had th to be continually sought for. A limestone of reasonably good quali found at a maximum carry of 10 kilometres from the road, and with a burden not exceeding 1 metre. Quarrying started at once, and cubic metres of stone had been quarried ready for crushing by April 1939 ; the output was $1\frac{1}{2}$ cubic metres per man per day.

Two Goodwin Barsby 20-inch by 9-inch portable crushers with belt elevators, fed by hand, crushed this stone $1\frac{1}{2}$ gauge down at the 8 cubic metres per hour. The crushed stone was left in stacks quarries to be loaded into dumpers by loading shovels and was led o road immediately before surfacing. Surfacing started early in Ap

The base course.

Three centimetres of crushed stone was led on to the road and sp auto-patrol over a width of $5\frac{1}{4}$ metres, and was rolled with an 8-to A Littleford distributor drawn by a D.4 tractor sprayed this with to the extent of 2 kilograms per square metre and the surface wa rolled.

The surface mat.

Crushed stone was led, in sufficient quantity to provide 8 cen of stone over a width of 5 metres, and was dumped in a windrow on of the road. This windrow was bladed across the road by auto and it was found that a layer containing most of the crusher dust chippings remained while the new windrow contained most of th stones and chippings and a few fines. The layer of fines was scre hand to extract the chippings for the later seal coat. The windr then flattened by auto-patrol into a bed $2\frac{1}{2}$ metres wide, and mixing over lengths of from 500 to 900 metres. 80-per-cent. bitumen at was sprayed on at a pressure of 35 lb. per square inch, and it wa necessary to use 55 kilograms per cubic metre of aggregate. This c was later found to give too dry a mix and was raised to 60 kilogr cubic metre. The work was started early in the morning. One qu

antity of bitumen was applied, and, while the distributor was being and heated, the bed of aggregate was cultivated with a spring-tooth . Following a second equal application of bitumen it was cultivated after which the auto-patrol turned the material over twice, and it across the road, leaving it again in a bed $2\frac{1}{2}$ metres wide.

urther equal application was followed by two cultivations and the ing quarter of the bitumen was added and cultivated once. The last tion was usually made by 11 a.m. The auto-patrol then completed xing by blading the material from one side of the road to the other, ips being required to transport the material; mixing was completed .m. The mixed material was spread by auto-patrol, and completed .m.

5 a.m. each morning one pass was made with an 8-ton roller travelling miles per hour, and the road was then opened for traffic; it was again at 4 p.m. Care was taken not to use the roller when the al was soft enough to show waves in front of the wheels.

at.

was planned to apply the seal coat before the winter of 1939, but one was sealed as an experiment about a week after mixing. A 5-metre bar distributed bitumen at the rate of $1\frac{1}{2}$ kilograms per square metre, e surface was blinded with chippings and then rolled.

mediately before the first rolling, material from the berm was brought hand to make an even joint with the stone mixture. In rolling, the e roller wheel was run partly on this material and partly on the mixture. After sealing, the auto-patrol was used for trimming the to continue the camber. It is reported that the resulting surface traordinarily good riding qualities at any speed, far surpassing those ed by means of hand spreading. It was also observed that a con- auseway with slopes of 1 in 40 could be crossed at 80 kilometres per ith scarcely perceptible vertical movement of the vehicle.

en supply.

was found that bitumen leaving Mafraq in the Thornycroft tank s at 150° F. arrived at the site at 125° F. after an 8-hour run. It und that a tanker could be held for 2 days before unloading, and 0-per-cent. bitumen could be unloaded at a temperature considerably 100° F. Normally, less than 10 minutes were required to fill the utor from the tanker.

e tractor proved ideal for towing the distributor, owing to the even maintained by the governor of the tractor. It was found that, in rging 1,000–1,200 U.S. gallons on a run of 700 metres, the total

output could be gauged to within 25 gallons. The heater raised th
perature in the distributor by 3–5° F. per minute, depending on w
the tank was hot or cold in starting.

The Lava Area.

Formation.

Three major re-alignments of the Iraq Petroleum Company's
totalling 15 kilometres, were made to avoid long steep grades, and to
the number of *wadi* crossings. In one case that road crossed the sam
wadi in six places, and the re-alignment reduced that number to tw
was decided that about one-quarter of the existing road would hav
regraded to eliminate acute vertical curves; bends would have
improved by increasing the radius, adding superelevation, and rais
soling where it had subsided. In this work a heavy rooter, draw
caterpillar tractor fitted with angle-dozer equipment, was first pass
the alignment. The rooter upturned any boulder up to about 1
dimension, and the angle-dozer pushed it off the formation. Any
rock required blasting, the bore-holes for the charges being mad
Holman compressor. This work was continuous over almost the
of the 100 miles of lava country. When the required grade ha
excavated a thickness of about 1 foot of lava-ash and soil was plac
consolidated above the rock as a bed on which 20 centimetres of
packed soling was laid, so that uneven consolidation of the soling
not occur, as had happened with the original soling.

Culverts were, in general, constructed of roughly-cut slabs of lav
producing a series of openings 2 feet wide. The end and wing walls
roughly-cut masonry in cement.

Wadis were crossed by causeways. Where the grade down to th
was not too severe, the bottom of the causeway was made at the l
the *wadi* bottom. In other cases an over-and-under causewa
constructed, the openings and drop-walls being faced with maso
cement, and a concrete roadway was provided.

Road metal.

Along the whole length of road lava-stones, in sizes suitable for cr
were piled in continuous heaps in the quantity required for sur
The tractor-driven 24-inch by 10-inch Goodwin Barsby crushers
between these heaps and the roadside. The tractor drove its c
through the rear power take-off, and then moved about a met
crushed again; by that means a continuous windrow of crushed
was left at the roadside.

Surfacing.

Mixing started after the Author had handed over the work
procedure planned in this section was that surfacing should start

ls, one end under control of the engineer at H.4, and one under the r at Mafraq. A number of D.2 tractors each towing a Millar mixer boiler, and operating the mixer through a rear power take-off, was along the soling. The mixers were to be fed by crushed metal he windrow beside the road, and, working in a similar way to the s, were to deposit a windrow of mixture on the road surface. The e was to be laid in two courses for a thickness of 10 centimetres and read by hand or by blade grader, each course being separately con-ed. Two courses appeared necessary to prevent minor inequalities old soling reproducing themselves in the finished surface. The rface was to be sealed with bitumen and blinded with chippings.

eral experiments were made to devise a means of reducing the cost better portions of the old surface, where some hand-work would ve been necessary in order to rectify small inequalities in the soling. stly, the earth surface over the sling was scarified, bladed, and sprayed ude oil from the pipe-line at the rate of 2 kilograms per square metre. d stone was added to an average depth of 5 centimetres, spread by atrol and rolled thicker at the crown than at the edges to provide a r. The centre half of the road was sprayed with bitumen at the 1 kilogram per square metre, and then the whole width was sprayed kilograms per square metre. This was rolled on the following g and $3\frac{1}{2}$ centimetres of stone added; at midday bitumen (2 kilo-per square metre) was sprayed on, and on the following day the was applied. This was repeated with another $3\frac{1}{2}$-centimetre layer he on the next day, and after a further 2 days the surface was with 2 kilograms per square metre, blinded with chippings, rolled, ened to traffic. The appearance was good, but the stones were not bound together as in the mixed sections.

e second experiment was conducted on an adjacent length of 500 . The base was similarly treated with crude oil and a depth of timetres of crushed stone was added. This stone was mixed by auto-with 60 kilograms of bitumen per cubic metre, as for the H.4 area 208), except that 20 kilograms per cubic metre of crude oil was after the first application of bitumen. In mixing, the scarified al from the original road was incorporated in the mix, and the crude s of great assistance in handling this added quantity of fines. This ent is said to show every promise of success, and it is now proposed he whole length from the east of the lava to H.5 should be blade-in this manner. This will greatly speed up the surfacing process, ing to the necessity of postponing the surfacing between H.4 and the r until next season, the plant for this work can be employed, leaving dle mixers free for work on the Mafraq sector.

Irbid to the Lava Belt.

The Irbid end of this sector has a considerably higher rainfall t sector to the east of the Hedjis Railway. The winter rain comin the west across Palestine is deposited on the ridges of hills, and the the rain is usually deposited on the Irbid escarpment and peters reaching the railway. Rainfall east of the railway usually comes f south in the form of isolated storms. The area stretching about metres east of Irbid is a rolling country of red clay and black cott which is good agricultural land but is impossible to work on for we time in winter. To the eastward the country then becomes more a hilly, until, a few kilometres short of the railway it becomes a barre desert plain; this continues to the lava belt.

It was decided that formation work should continue as far as from the railway towards Irbid before the rain set in, and if poss formation was to be completed to allow consolidation by rain befo On the flat desert, formation and soling work would be possible thr the winter. The whole length was to be fully bridged, but as no st of rainfall and run-off were available, bridging was not to be start observations had been made during the winter.

While waiting for the plant, which was not due for delivery u August, work was concentrated on quarrying and collecting st soling and surfacing. Although outcrops of limestone occurred al the alignment, in most sections a sound stone was difficult to find a carry of 10 kilometres. A quarry was operated by direct labo stone was supplied from this over a length of 10 kilometres of road. ascertained the cost of extraction, the road was divided into len about 10 kilometres, and tenders for the quarrying and collection for each length were put out to contract. All stone was on the r by the end of 1938.

In August a blade grader was put to work ditching, crowni shaping the formation on the flat well-drained section east and the Hedjis Railway, and the training of the soling gangs comm By September two gangs, each of a hundred men, were employed the railway, and they had worked up to an output of 10 square met man per day, stone being piled ready at the roadside. The outp therefore 400 metres of road per day. When the rains came, fi gang, and later the second gang, were transferred to the east of the r

One of the elevating graders from H.4 was transported to Irbid, one month raised a formation of the same specification as at H.4 10-kilometre length of cotton soil east of Irbid. On this section and-fill work was performed by a 12-yard carry-all scraper, assiste heavy rooter to break up the rock. Any hard-rock formation wa shaken by explosive in bore-holes. The angle-doser was used o lengths of cut and in filling-in culverts and bridge abutments. The

aper proved a most useful and economical machine for cut-and-fill so long as continuous employment could be found for it. The angle- could not compare with it on this work except on very short cuts, ere large pieces of rock had to be moved. In all except a few minor and laying charges in blasting, all formation work was carried out by nes, and by the beginning of 1939, when rain stopped further work formation, only about 8 kilometres remained to be completed.

particularly heavy early rainfall occurred in November over the sector from Palestine to the lava. At Mafraq the rainfall in 48 hours 3 inches, an inch more than the average for a whole year. All the *wadis* between the railway and Irbid ran at a depth of about 2 metres. naximum flood heights of all *wadis* were recorded. The local Arabs unanimous that this was the highest flood they had ever experienced s area. The flood heights observed were quite twice that estimated e engineers from the observation of erosion marks on the banks. omenally heavy floods were occasioned by the same storm in Palestine. floods were a fortunate occurrence as many of the *wadis* never, ran more than a few inches deep throughout the following winter. tunately this rainstorm did not extend beyond the west edge of the belt.

fter the floods it was decided to bridge fully the road from the Jordan e Hedjis Railway, and work was started on bridges and culverts. orced-concrete pipes of 36 inches diameter were used singly, or in s, for the smaller openings, whilst for spans up to 4 metres, reinforced- ete slabs were adopted. For larger spans, heavy bridges of steel hing were built to the standards of the Crown Agents for the Colonies, multiple 20- and 30-foot standard spans. All such bridges had nry-faced abutments, piers, and wing walls filled with rubble cement ete. On the average, three waterways per kilometre were required, n the 42 kilometres from the railway to Irbid there were six bridges, f 90-foot span, two of 70-foot span and three of 20-foot span, respec- .

he latest information shows that the work is closely following the ate of cost, and it is confidently expected that the work will be com- l on time.

ACKNOWLEDGEMENTS.

he Author wishes to express his appreciation to the Shell Company of t for placing Mr. J. Flemming, one of their road engineers, and several en experienced in bitumen application and the running of road , at his disposal, and for all the assistance that their wide experience led. Thanks are due also to the Near East representative of the pillar Company for his advice and weeks of personal training of

operators, and for putting his experience of American road work a
Author's disposal.

The Paper is published by permission of the War Office and t
Institution of Royal Engineers, Chatham.

The Paper is accompanied by two drawings, from which Plates
the Figure in the text have been prepared, by twenty-two photog
and by the following Appendixes.

APPENDIX I.

Plant purchased.

Four	Holman T.18.D. compressors, having an output of 180 cubic f minute, driven by 40-brake-horsepower Dorman diesel engine mounted on pneumatic-tired carriages.
Three	20-inch by 9-inch Goodwin Barsby cast-steel jaw crushers, dri 30-brake-horsepower Lister diesel engines and mounted on ste carriages.
Three	Goodwin Barsby 16-inch-wide belt portable elevators driven by 3½ power Lister petrol engines.
Four	24-inch by 9-inch Goodwin Barsby cast-steel jaw crushers moun steel-tired carriage and driven through universal shaft by a D.4 pillar 40-horsepower tractor from a rear power take-off. The ma were designed to the Author's specification. There was enough cle to allow the crusher to deposit a windrow of crushed stone sufficie surface 10 centimetres thick over a road width of 5 metres.
Eight	Millar's paddle mixers each with a 10-cubic-foot mixing-box mount steel-tired carriage. A mechanical bitumen pump was incorporate the whole was driven through a universal shaft from the rear powe off of a D.2 20-horsepower caterpillar tractor.
Eight	Bristowe bitumen-heaters, each of 320-gallon capacity and an of 200 gallons per hour, heated by Rutherford oil-burning ment. Each was equipped with a standby hand-operated bitumen and was mounted on a pneumatic-tired chassis. These heaters towed behind the mixers by the tractors and the three machine operated as one unit. The axle clearance allowed the plant to c a windrow of mixed material sufficient for a surface 10 centimetre over a road width of 5 metres. The heaters and mixers were sp designed to the Author's specification for work in combination wi tractor-driven crushers. Spreading the windrow of bitumen macad a blade grader reduced labour to a minimum for this process.
One	Littleford Model C bitumen heater and distributor having a capa 1,250 U.S. gallons, mounted on a 4-wheeled trailer-chassis with du pressure tires.
Twelve	Aveling DX.8 single-cylinder 8-ton diesel rollers.
Six	Aveling DY.10 single-cylinder 12-ton diesel rollers.
Two	pneumatic drill-sharpeners with oil-fired furnaces.
Six	D.4 caterpillar tractors, three of which were used for general hau plant, and three for operating the crushers.

D.2 caterpillar tractors for operating the mixers.
Muirhill ½-cubic-yard loading shovels.

rt vehicles purchased.

Thornycroft 106-brake-horsepower "Amazon" petrol-engined tractors with three-axle cross-crountry chassis mounted on low-pressure tires.
Carry-more semi-trailers with platform bodies mounted on dual rear axles to carry loads of 15 tons, drawn by Thornycroft tractors (see above).
Carry-more semi-trailors mounted on single rear axles carrying insulated 2,000-gallon bitumen tanks, drawn by Thornycroft tractors (see above).
Ford "V.8" utility car.
Chevrolet coupé "pick-up" cars.
Chevrolet 5-seater saloon car.
Chevrolet utility cars.
Chevrolet 1-ton "pick-up" trucks.
Chevrolet 2½-cubic-yard tipping-lorries.
Chevrolet 500-gallon water-tank lorries.
n Muirhill 2½-cubic-yard dumpers.

Plant.

R.D.8 caterpillar tractors.
R.D.7 caterpillar tractor.
Le Tourneau heavy rooters.
angle-dozers.
Le Tourneau model K carry-all scraper of 12 cubic yards capacity.
caterpillar No. 66 blade grader.

tor's Plant.

R.D.7 caterpillar tractors.
R·D.8 caterpillar tractor.
caterpillar No. 42 elevating graders with 22-foot carriers.
Le Tourneau carry-all scraper of 12 cubic yards capacity.
caterpillar No. 66 blade grader.
caterpillar No. 12 auto-patrol.
John Dere spring-tooth harrow.

caterpillar tractors, road rollers, and bitumen heaters ran successfully on crude n the Iraq Petroleum Company's pipe-line.

APPENDIX II.

stract of specification for contractor's work on the section of the road from east lava belt to the Transjordan–Iraq frontier.

Formation.

A formation, ½ metre high and 8 metres wide on top, was to be raised and consolidated over the whole 90-kilometre length as shown in *Fig. 2* (p. 206) and was to be finished to shape and grade. The formation was to lie throughout one winter's rain to assist consolidation. Payment was to be made by the cubic metre of soil after consolidation.

(2) The base course.

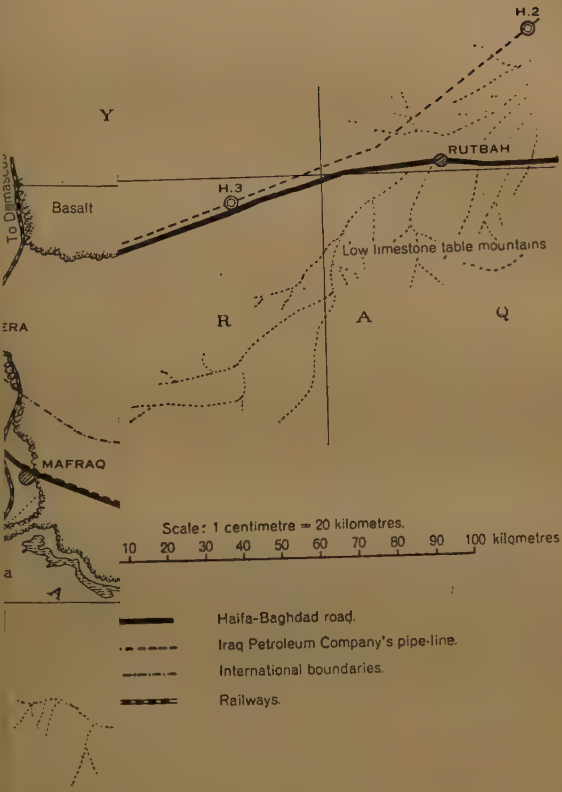
Crushed stone was to be supplied by the War Department on to th
The contractor was to spread a base course, 3 centimetres thick, spray w
bitumen (supplied by the War Department), and roll it. This course a
provide a clean smooth bed so that the surface coat could be mixed in sit

(3) The surface mat.

Further crushed stone (supplied on to the road by the War Depar
was to provide a carpet 8 centimetres thick, making a total consolidated
ness of 10 centimetres. The contractor was to spray this with bitumen
spread with an auto-patrol, and finally to consolidate it. A power spray
crude fuel oil (from the Iraq Petroleum Company's pipe-line) were to b
plied by the War Department.

PLATE 1.

THE HAIFA-BAGHDAD ROAD.



R. BRIGGS.

Paper No. 5205.

'he Hydraulic Problem Concerning the Design of Sewage-Storage Tanks and Sea-Outfalls."

By JOHN RUPERT DAYMOND, M.Sc., Assoc. M. Inst. C.E.

Ordered by the Council to be published with written discussion.) [1]

TABLE OF CONTENTS.

NOTATION.

nless otherwise stated, all dimensions are in foot-second units.

A denotes the area of the tank.
d ,, ,, diameter of the outfall.
D ,, ,, minimum value of z.
f ,, ,, coefficient of friction, taken as 0·01 in all examples.
g ,, ,, acceleration due to gravity.
h ,, ,, difference in height between the tank- and tide-levels at time t (that is, $z - \zeta$).
H ,, ,, maximum value of z.
k ,, a factor involving L, d, and f (p. 232, equation (13b)).
L ,, the length of the outfall.
m ,, ,, fraction Q/A.
q ,, ,, rate of flow through the outfall.
Q ,, ,, rate of flow into the tank.
$2R$,, ,, range of the tide.
s ,, ,, fraction Q/k.
t ,, ,, time.
T ,, ,, period of the tide in hours.

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[1] Correspondence on this Paper can be accepted until the 15th May, 1940, and e published in the Institution Journal for October, 1940.—SEC. INST. C.E.

z denotes the tank-level at time t measured above and below
tide-level.
α ,, ,, fraction k/A.
Δ ,, ,, depth of the tank.
ζ ,, ,, tide-level at time t measured above and below
tide-level.

Abbreviations.

Outfall. This term refers to the sewer, one end of which discharge the sea, the other end being connected to the sewerage syster

"Unit tide." This term denotes a tide with a range of 2 feet (t $R = 1$ foot) and a period of 1 hour (that is, $T = 1$ hour).

(Note :—symbols having the suffix 0 refer to "unit tide.")

"z-curve." This refers to the curve of tank-level plotted on a time l

"Periodic z-curve." This term refers to the hypothetical "z-c which the actual "z-curve" approaches asymptotically.

"α-constant curves." This term refers to the curves of H_0 and D_0 p against m_0, α being constant.

"H_0-constant curves" and "D_0-constant curves." These terms re the curves of m_0 plotted against s_0, H_0 and D_0 respectively being con

Introduction.

Under suitable conditions, a convenient and economical means o age-disposal for places situated on, or near to, the sea coast, is to disc the sewage into the tidal water, purification being effected by dil This is usually done by conveying the liquid for disposal through outfall sewer, the outlet end of the outfall being equipped with a tid to prevent back flow of the tide into it. In addition, the end is u fixed below the low-water level of all tides. In design, once the o position has been located, the main points to be considered are a entirely hydraulic in character and, to the Author's knowledge, no ade discussion or satisfactory solution has appeared in connexion wit problems that arise.

If the sewers are tide-locked during a period of each tide, the disc to the sea may be continued by pumping, or on the other hand, stor tanks may be adopted for the period of tide-lock. In general, pur schemes may be designed by standard methods and the hydraulic pr is straightforward. The problem of storage, however, is far more inv and it becomes necessary to deal with the design of the outfall and st tank.

The scope of the present Paper is to discuss and solve the hyd problems connected with the design of sea-outfall sewerage scl involving storage. To restrict the complexity of the problem it is ass

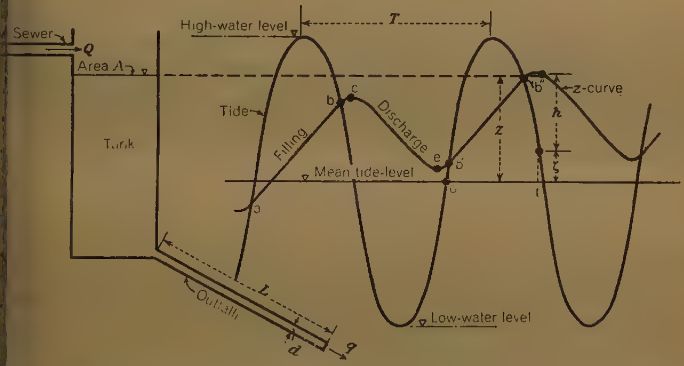
) the rate of flow of the sewage into the storage tank is constant, area of the storage tank is constant, (c) discharge to the sea is per-e at all stages of the tide, and (d) the end of the outfall, provided tide-flap, is below low-water level at all times.

e problem reduces to a differential equation which cannot be solved tly, whilst an algebraic solution is too involved to be of practical The problem is, therefore, dealt with experimentally on a model reproduces the actual conditions. The results thus obtained are nted graphically by a family of curves in such a manner as to be ctical use. It is further shown how these results, although given " unit tide" of fixed dimensions, may be transformed and applied tide of similar shape to the "unit tide."

THEORY.

. *1* shows curves representing tank-level and tide-level on a common ase. Commencing discussion of the curves at the point a, there is

Fig. 1.



harge between a and b and so the tank fills at a uniform rate until when the tide-level falls below the tank-level. The tank-level con- to rise until q is equal to Q. This occurs at the stationary point he tank-level curve (the "z-curve"). From c the tank-level falls is again equal to Q at e, the difference between tide- and tank- being the same at c and e. Between e and b′, q is less than Q and at harge ceases, and a new cycle commences. Thus, for each tide, is a curve of discharge and filling showing the variation of tank- This is the "z-curve" (see p. 218).

king heights upwards from mean tide-level as positive and assuming triction to the depth of the tank., let the tank-levels be z and $z + \delta z$ es t and $t + \delta t$, respectively. Then in the interval δt the volume of

inflow is $Q\delta t$, the increase in storage is $A\delta z$, and the volume of disch $q\delta t$. Hence:

$$Q\delta t = A\delta z + q\delta t.$$

Since the end of the outfall is below low-water level, q will depen on h, the difference between the tank- and tide-levels. Writing:

$$\alpha = k/A \text{ and } m = Q/A, \quad \ldots$$

adopting the usual hydraulic formula:

$$q = kh^{\frac{1}{2}}, \quad \ldots$$

and proceeding to the limit, then:

$$\frac{dz}{dt} = m - \alpha h^{\frac{1}{2}}. \quad \ldots$$

It is presumed, of course, that the outflow q has no effect upon th levels, so that ζ will be a known function of t.

Equation (3) is valid for positive values of h only; since, how there can be no flow from the tide to the tank, then for $h \leq 0$,

$$\frac{dz}{dt} = m \quad \ldots$$

It is clear, then, that equation (3) refers to the discharge and equat to the filling parts of the "z-curve", as shown in *Fig. 1*, whilst the equations together completely define a "z-curve", since consta integration may be chosen to ensure continuity for all values of t. be convenient to write:

$$\frac{m}{\alpha} = \frac{Q}{k} = s \quad \ldots$$

Equation (3) then becomes:

$$\frac{dz}{dt} = m\left(1 - \frac{\sqrt{h}}{s}\right) \quad \ldots$$

Since, for any particular case, Q will be a known constant, it w seen from equations (1) and (5) that s and m are inversely proportio k and A respectively. Therefore m may be regarded as a "tank fa and s as an "outfall factor."

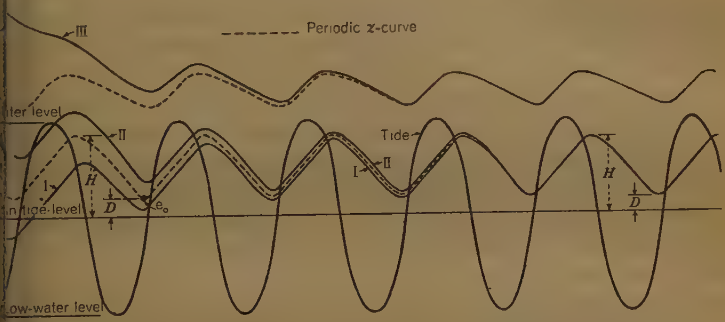
"*Periodic z-curves.*" For fixed values of m and s there are an i number of solutions of equation (6), depending upon the consta integration. All solutions of equation (6) approach the "periodic z-c asymptotically (this latter being, itself, one solution) provided th tide is periodic [1]. Thus, whatever the position of b'' with respect to *Fig. 1*), the "z-curve" approaches, and ultimately becomes coin with, the "periodic z-curve." A "periodic z-curve" is comp

[1] Dr. A. G Walker, and J. R. Daymond, "On a Hydraulic Problem Involvi charge into Tidal Water." *Phil. Mag.*, vol. 28 (1939), p. 520 (November, 193

ined by any one value of m and a corresponding value of s. This ant property of the "z-curve" is illustrated in *Fig. 2*, where the I and II are drawn for the same values of m and s, but for different g conditions; curve I starts below and curve II starts above the ttled state. Curve III of *Fig. 2*, which is obtained for values of m different from those adopted in deriving curves I and II, is an e of a case in which the outflow is continuous, that is, the tank- always above tide-level. Theoretically, the "z-curves" attain city in an infinite time. As shown in *Fig. 2*, however, they become c after a definite number of tides, the time taken depending upon aration of the initial curve from the periodic curve.

H and D, *Fig. 2*, be the respective maximum and minimum heights periodic z-curve." Then for a given tide, H and D are determined n values of m and s. Conversely, corresponding to given values of

Fig. 2.



D, m and s will be determined. Hence, it may be shown that of r factors H, D, m, and s entering into the problem, any two may sen quite arbitrarily, in which case the other two are fixed. The n between these four factors will be discussed in more detail later, practice it will be found that H, regarded as the highest permissible vel, is usually fixed, so that there remains one degree of freedom. eans that one of the factors, or combination of factors, such as cost, e fixed at will. In *Fig. 2* the top and bottom of the tank are H respectively above mean tide-level. If, then, the tank is empty at e_0, never overflow or fail to empty itself completely on successive nt tides. It is evident that the "periodic z-curve" is the essential consider and, since its shape is not the primary concern, only the H and D for the curve need be considered. From the corresponding of m and s, giving this "periodic z-curve", the size of the tank e outfall for the given value of Q can be derived. Finally, then, in ng a scheme, H, D, m, and s are the factors concerned, but, at the ime it is essential to derive results for a "periodic z-curve." If a

design is based on results obtained for a curve other than the perio
then on succeeding tides the conditions will change and the desi
be unsuitable or uneconomical.

Furthermore, it is not sufficient to base a design on one tide o
will be necessary to consider the effect of variations which take plac
tank levels, and more particularly in H and D, consequent upon the
change of range between spring-tides and neap-tides. This e
point will be dealt with later, where it will be shown how a soluti
tained for any one tide, may be utilized to give results for any ot
of similar shape, but of different period and range.

Methods of Solution. If, as is usually assumed in representin
ζ is a trigonometrical function of t, it will be seen, on substitu
$z-\zeta$ for h, that equation (6) cannot be solved explicitly. Two a
mate solutions are possible, one graphical and the other algebraic ;
method is suitable for obtaining a complete set of results, but the gr
method offers a convenient means of checking any particular result o
by experiment, as explained in the Appendix (p. 235). An algebraic s
may be derived by assuming the tide curve to consist of parts of s
lines and parabolas, but the solution is not in a form suitable for

Having regard to the difficulties of deriving useful results by th
was found necessary to resort to experiment in an effort to ob
complete solution. A model was therefore constructed to reprod
conditions of the problem, and a series of results has been obtained.
results are displayed in Fig. 9, Plate 1, which shows superimposed f
of curves drawn with m and s as co-ordinates, one set of curves
drawn for various constant values of D and the other set for v
constant values of H.

Transformation Equations. It is evident that any results obtai
experiment on a model should be capable of general application. I
to transform results derived under one set of conditions to those of a
set of conditions, it is first of all necessary to know how the m
related to its prototype, and, knowing this, how the results are af
Assuming the law of hydraulic flow to be the same in the model as
prototype, it is necessary to know whether any results for anoth
can be deduced when all other solutions for one particular tide are k

Assuming a sine tide curve [1] of range $2R$ and period T, then :

$$\zeta = R \operatorname{Sin} 2\pi t/T,$$

t being measured from a suitable origin. Writing $h = z - \zeta$ and
tuting for ζ, equation (3) becomes :

$$\frac{dz}{dt} = m - \alpha\left(z - R \operatorname{Sin} \frac{2\pi t}{T}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad .$$

which is the equation to the "z-curve."

[1] The following is true for any periodic tide, but for simplicity it is conve
adopt a sine curve.

, let the tide considered above be changed to another of range $2R_0$ riod T_0, so that the heights and times are changed in the ratio nd T_0/T, respectively. This change or transformation may be d alternatively as retaining the first tide curve, but altering its scale in the ratio R_0/R and its horizontal or time scale in the ratio give the second tide with its range R_0 and period T_0.

he same way, let the "z-curve" be transformed with respect ht and time so that, in addition to the ratios already given, R_0/R. Then:

$$z_0/z = \zeta_0/\zeta = R_0/R \text{ and } t_0/t = T_0/T. \quad . \quad . \quad . \quad . \quad (8)$$

ce $Rdz_0 = R_0dz$ and $Tdt_0 = T_0dt$.

stituting in (7) from (8) for z and t in terms of z_0 and t_0, then:

$$\frac{dz_0}{dt_0} = m\frac{TR_0}{T_0R} - \alpha\frac{T}{T_0}\left\{\frac{R_0}{R}\left(z_0 - R_0 \text{ Sin } \frac{2\pi t_0}{T_0}\right)\right\}^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad (9)$$

ring now the second tide and "z-curve" with suffix 0, the equation erived in the same way as equation (7), is:

$$\frac{dz_0}{dt_0} = m_0 - \alpha_0\left(z_0 - R_0 \text{ Sin } \frac{2\pi t_0}{T_0}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad (10)$$

ter equation is similar in all respects to (9) if:

$$\frac{m_0}{m} = \frac{TR_0}{T_0R} \text{ and } \frac{\alpha_0}{\alpha} = \frac{T}{T_0}\left(\frac{R_0}{R}\right)^{\frac{1}{2}}.$$

refore, provided m and α have the relationship given above, any to the first tide given by equation (7) may be utilized to give a to the second tide, since, it is important to note, m and α depend on the range and period of the tide. Thus, the solution for any one y be transformed to give the solutions for any other tide and, in lar, the transformation may be applied to the "periodic z-curve." e the peaks H and D correspond to the maximum and minimum of z, the ratios given in equation (8) may be extended to include:

$$\frac{H_0}{H} = \frac{R_0}{R}, \text{ and } \frac{D_0}{D} = \frac{R_0}{R},$$

addition, from equation (5) and the preceding ratios:

$$s\sqrt{R_0} = s_0\sqrt{R}.$$

se equations of transformation may be used in a variety of ways, amples of their application to practical problems will be given later. most useful immediate application, however, is in expressing ex- ntal results in a standard form so that they can be conveniently rmed and applied to any practical case. If, therefore, results for tide are known (no suffix) and it is required to examine the results

for another tide (suffix 0), the equations of transformation, already d
but collected here for convenience, are :

$$\frac{m_0}{m}=\frac{TR_0}{T_0R}, \ \frac{\alpha_0}{\alpha}=\frac{T}{T_0}\left(\frac{R_0}{R}\right)^{\frac{1}{2}}, \ \frac{s_0}{s}=\left(\frac{R_0}{R}\right)^{\frac{1}{2}}, \ \frac{H_0}{H}=\frac{D_0}{D}=\frac{R_0}{R}.$$

"*Unit Tide.*" For any one place a tide may have a wide varia
range, its period remaining constant. Hence, assuming consiste
form of tides, it is obviously an advantage to give results for a st
unit tide from which results for other tides may be derived. F
purpose, a tide with a range of 2 feet, that is, R = 1, and period of
has been adopted, and all experimental results are given with refer
this "unit tide."

If, therefore, the quantities with suffix 0 refer to the unit tide, an
without suffix to any other tide, then the equations of transfor
are :

$$m_0=m\frac{I}{R}, \ \alpha_0=\alpha\frac{T}{R^{\frac{1}{2}}}, \ s_0=\frac{s}{R^{\frac{1}{2}}}, \ \frac{H_0}{H}=\frac{D_0}{D}=\frac{I}{R}, \quad . \quad .$$

T being measured in hours, since R_0 is unity and the period T_0 is 1 h

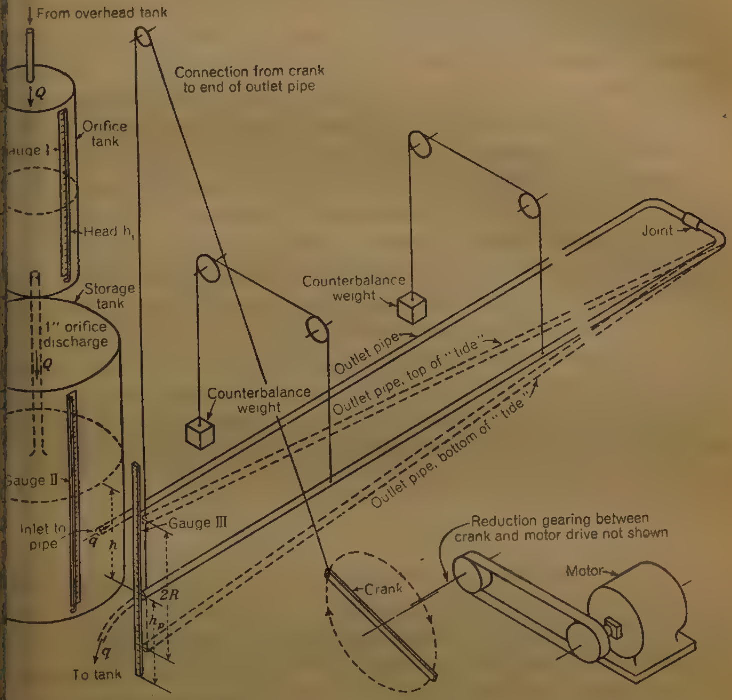
Experiment.

Description of the Model. An outline diagram of the model-ap
on which the experiments were carried out is shown in *Fig.* 3
diagram is not to scale, and to make it clear, unessential featu
omitted. The apparatus consists of a storage tank which receives
Q from an orifice tank, this flow being discharged at a rate q thro
outlet-pipe. At the same time, the end of the outlet-pipe is perio
raised and lowered by means of a connection from a rotating cran
simulating a head relative to the water-level in the storage tank
conditions in the model are thus the same as those prevailing in
Q corresponding to the sewage flow, while the oscillating outlet-p
addition to its correspondence to the outfall, serves to create th
head. In nature, tidal levels are independent of any commen
discharge from an outfall, a condition which is simply and effective
filled in the model, since the level of the end of the outlet-pipe is in
dent of q.

The supply Q, obtained from an overhead tank (not show
measured on gauge I, giving the head over a 1-inch-diameter orifice
orifice tank, flows to the storage tank and hence through a 2-inch-di
outlet-pipe to a tank (not shown) in the base of the building. The
discharge was accurately calibrated, by direct weighing, to give Q in
of h_1, the head measured on gauge I. The maximum area of three
connected storage tanks (two of which are omitted from the di
Fig. 3) is 13·82 square feet. By inserting drums in the tanks, or
connecting them, this area could be reduced to a minimum of 2·324

The outlet-pipe, 78 feet 6 inches long, is fixed from its connexion to rage tank, to a joint which is between two right-angle bends, the der of the pipe being free to move about this joint in a vertical To prevent sagging and to ensure steady motion, counter-balance s were suspended over pulleys and connected to the moving outlet-

Fig. 3.



as shown. The end of the outlet-pipe was raised and lowered in nic motion by means of a wire-rope connexion which passed over ey to a rotating crank. The connexion being over 12 feet long, the level curve", corresponding to the motion of the end of the outlet- was almost a true sine curve, since the obliquity between the crank he end was very small. The crank was driven through belt and g (no details of the gearing are shown) so as to give tide periods g from 124 to 750 seconds. This period could be changed for nt sets of experiments by changing the pulleys on the driving-motor and also by a variable resistance control on the line voltage in series the field and armature. The resistance was also used to ensure a nt motor-speed for each experiment.

e head of water in the storage tanks was measured on gauge II, and

the level of the end of the outlet-pipe on gauge III, the datum c these gauges being accurately fixed at the same level. All the could be read to 0·005 feet. The discharge q was calibrated in of h, the difference in the readings on gauges II and III. The equa the rating curve of q in cusecs for $h \geqslant 0{\cdot}11$ feet is $q = 0{\cdot}032\ h^{\frac{1}{2}}$.

The Method of carrying out Experiments. Although m and s a co-ordinates of the desired families of curves, it was not found conv to carry out experiments keeping either m or s fixed, and varying the From the form of the model, a set of results could be most conve obtained by keeping A, T, and R constant and varying Q. Since th size of outlet pipe was used throughout, k was fixed, so that each experiments were carried out for fixed values of α, T, and R. Fo experiment, the procedure was to start with a known constant Q (and a known value of m, since A was fixed), and to run the apparatus at determined constant speed to give a constant value of T. Readings on II were then noted until h became periodic to give a "periodic z-cu with constant maximum and minimum readings on a number of succ tides. These peak values were then tabulated as H and D, using the of the tide-level, as read on gauge III, as datum. Changing Q, the ment was repeated for another value of m, both T and R rem constant. Sets of results were obtained in this way and plotted t "α_0-constant" curves, H_0 and D_0 being plotted against m_0 after forming by equation (12) from the experimental to the "unit tide."

Experimental Results.

Ten sets of experiments were carried out with α_0 ranging from $\times 10^{-4}$ to $28{\cdot}44 \times 10^{-4}$, the resulting "$\alpha_0$-constant" curves for H D_0, plotted against m_0, being given in Figs. 4 and 5, Plate 1.

When H and D are large compared with R, the head producing dis tends to become independent of the tidal fluctuation, and may th measured from mean tide-level instead of from the actual tidal Hence, in equation (6), dh/dt may be written for dz/dt and, as a res can be seen that:

$$H = D = s^2.$$

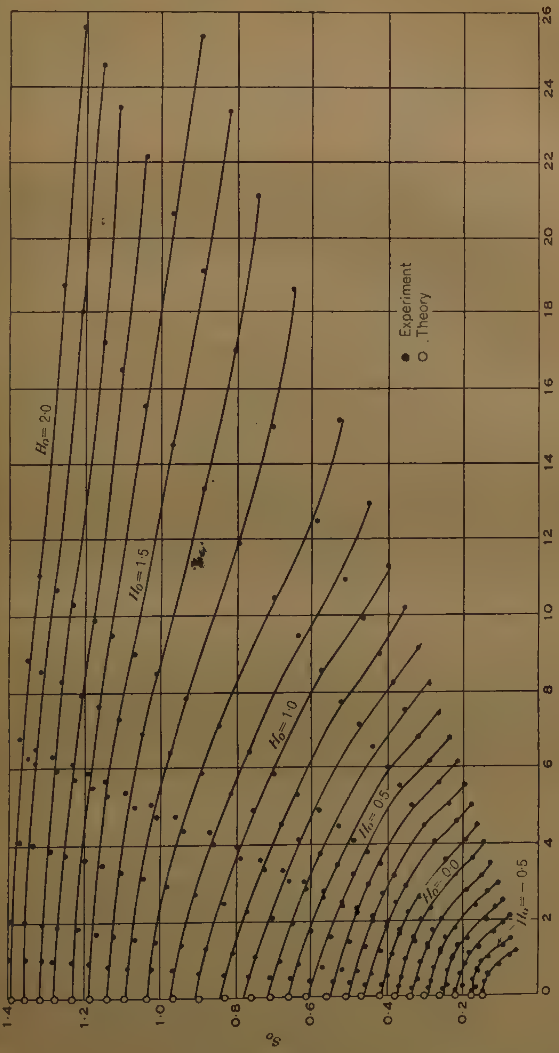
Since $s = m/\alpha$, it follows that the asymptotes to the "α_0-constant" are given by the equations:

$$H_0 = m_0{}^2/\alpha_0{}^2 \text{ and } D_0 = m_0{}^2/\alpha_0{}^2.$$

The asymptotes to some of the curves, calculated from these equatio shown as broken lines in Figs. 4 and 5, Plate I. The H_0-curves lie abov the D_0-curves below, their corresponding asymptotes, and, as H_0 a increase, they will approach each other, and finally come together appropriate asymptote. This indicates that, in the limit, the level

tank remains constant, and the inflow Q is, at all times, equal to the
q. These asymptotes, which were easily derived, provided a very
check on the accuracy of this initial representation of the experi-
results.

Fig. 6.

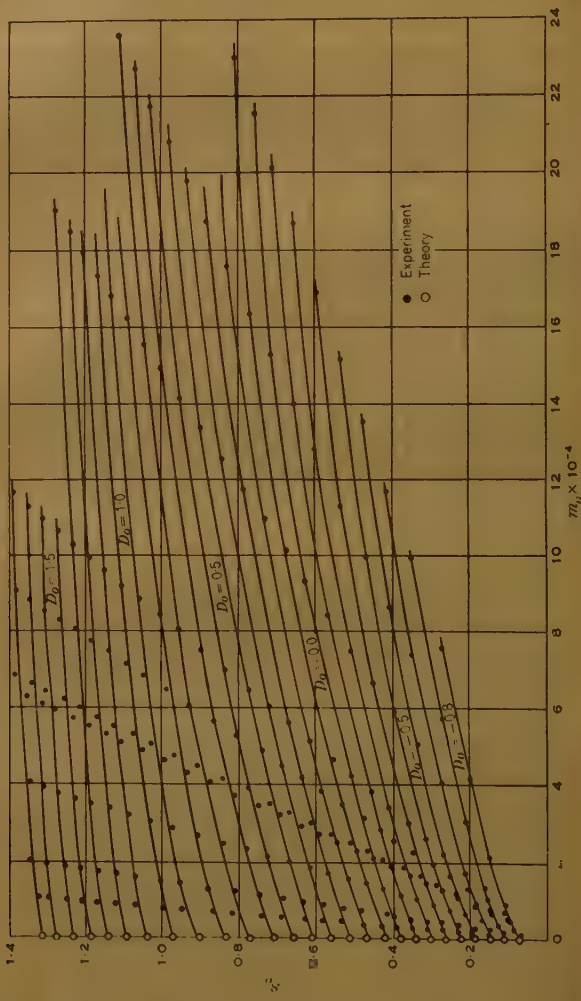


"H_0-CONSTANT" CURVES.

"α_0-constant" curves do not give the results in the most useful or direct practical use. They were, therefore, transposed into a convenient form of "H_0-constant" and "D_0-constant" curves with s_0, as co-ordinates. The "H_0-constant" curves, *Fig. 6*, were obtained

from Figs. 4, Plate 1, by taking a fixed value of H_0 and finding va
m_0 where an H_0-line, drawn parallel to the m_0-axis, cuts the α_0-curves
a given value of H_0, it was thus possible to determine corresponding
of m_0 and s_0, and hence to plot the "H_0-constant" curve.[1]

Fig. 7.



"D_0-Constant" Curves.

"D_0-constant" curves, *Fig.* 7, were derived in the same way from F
Plate 1. Both sets of curves in *Figs.* 6 and 7 are drawn in inter
tenths, H_0 being given from —0·6 to 2·0 and D_0 from —0·8 to 1·9.

If m_0 and α_0 are both very small but the ratio s_0 finite, it may be s

[1] Dr A. G. Walker, and J. R. Daymond, "On a Hydraulic Problem In
Discharge into Tidal Water." *Phil. Mag.*, vol. 28 (1939), p. 520 (November,

e points on the s_0-axis, where H_0 is equal to D_0, may be calculated he elliptic integrals :

$$s_0 = \frac{1}{\pi}\int_{-H_0}^{1} \left(\frac{H_0 + x}{1 - x^2}\right)^{\frac{1}{2}} dx, \text{ for } H_0 \leqslant 1,$$

$$s_0 = \frac{1}{\pi}\int_{-1}^{1} \left(\frac{H_0 + x}{1 - x^2}\right)^{\frac{1}{2}} dx, \text{ for } H_0 \geqslant 1.$$

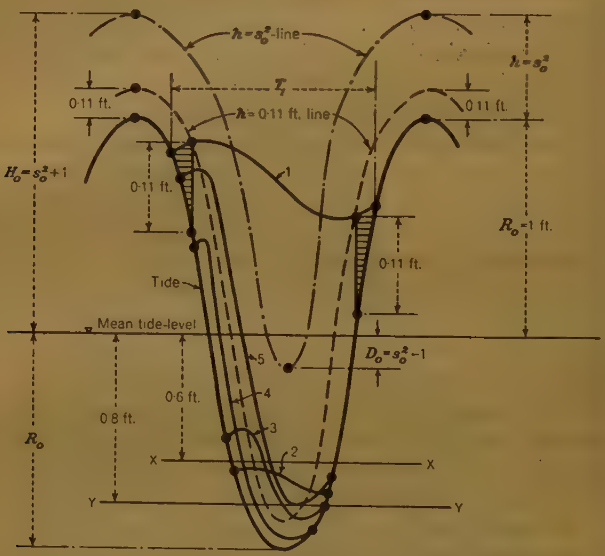
ints obtained from the evaluation of the above integrals are shown ll circles in *Figs. 6* and *7*. It is seen that the curves, drawn to pass h the points obtained by experiment, also tend to pass through these ical end-points, thus demonstrating very clearly the close agree- etween the theoretical and experimental results.

ilst it may not be strictly true, it is reasonable to presume that the will be sufficiently accurate if it is assumed that the law of discharge, by equation (2), holds in nature. Hence, by the laws of hydraulic ude, all experimental results are transformable for the values of hich equation (2) is true for the model, since the equations of trans- ion were derived on the assumption that the law of discharge is ently true in all cases. When h was less than 0·11 foot, the flow in odel no longer conformed to equation (2). Hence, "z-curves" always less than 0·11 foot cannot be transformed, since the laws of ge for the model and in nature are now different. In every "z-" there will be a part where h is less than 0·11 foot, as indicated by aded regions of the diagram for curve 1, *Fig. 8* (p. 230). Hence, a ve" cannot be accurately transformed for the whole time of dis- T_1. For cases likely to arise in practice, however, the time during h is less than 0·11 will be small compared with T_1, both for the and in nature, so that the error introduced by transformation will very small.

ves for H_0 less than $-$ 0·6 foot and D_0 less than $-$ 0·8 foot have not ncluded in the results, and are therefore omitted from *Figs. 6* and nce, any curve such as curve 2, *Fig. 8*, with its maximum below e X X at 0·6 foot from mean tide-level, is excluded, and a curve such ve 3, with its minimum below Y Y at 0·8 foot from mean tide-level, excluded. These curves are not important, since they lie in regions ely to be used in practice. It will be noted that any "z-curve" s curve 4, *Fig. 8*, which is wholly within the space bounded by the rve and the dotted curve drawn at a height of 0·11 feet above the as its minimum below Y Y and is excluded from the experimental , since it is another case of curve 3. The greatest error of trans- ion from the family of "D_0-constant" curves will arise for curves are near to the $h = 0{\cdot}11$ line and for which $D_0 = -$ 0·8, as illustrated

by curve 5, *Fig. 8*. As D_0 increases the " z-curves " approach the t curve 1, where h will be large for the greater part of the discharge] Hence, it is clear that the accuracy of transformation will increase increases. It is only in exceptional circumstances that it is necess design a scheme with D_0 small, and so, for most practical purpose results given in *Figs. 6* and *7* may be used with a very reasonable of accuracy. In any case, before finally accepting the experimenta tion as a basis for design, it is always advisable to check results graphical method given in the Appendix (p. 235).

Fig. 8.



Considering the " unit tide ", equation (3) may be written

$$\frac{1}{m_0}\frac{dz}{dt} = 1 - \frac{h^{\frac{1}{2}}}{s_0}.$$

When m_0 and α_0 are both very large, but s_0 is finite, the left-hand s this equation becomes very small, and in the limit $h = s_0^2$. This that the " z-curve " follows the tide and is at all times a height s_0^2 ab as shown by the chain-dotted curve, *Fig. 8*. From the figure it is clea for $H_0 > 1$,

$$H_0 = s_0^2 + 1,$$

thus giving the equations to the asymptotes of the appropriate constant " curves of *Fig. 6*. For H_0 less than 1, it may be easily that the " H_0-constant " curves will cut the m-axis. Since it lead discussion of a region for which no experimental results are availal

purpose is served in pursuing the theory. However, it is interesting e in *Fig. 6* the tendency for the curves, for which $H_0 \geqslant 1$, to be totic as m_0 increases, and for the remaining " H_0-constant " curves the m-axis. The " D_0-constant " curves are asymptotic for all of D_0 and are given by the equation :—

$$D_0 = s_0^2 - 1$$

y be seen from *Fig. 8*. The asymptotic properties of the curves are seen in *Fig. 7*.

om the foregoing discussion, useful and substantive information has btained concerning the behaviour of the " H_0- " and " D_0-constant " for which no experimental results can be known, that is for m_0 zero, r m_0 very large. Not only was it thus possible to confirm some of perimental results, but also this theoretical information enabled the to be drawn with confidence and accuracy.

DISCUSSION ON THE VALUE OF THE EXPERIMENTAL RESULTS.

e curves of *Figs. 6* and *7*, with the theoretical and experimental omitted, have been combined in one diagram, Fig. 9, Plate 1, H_0- and D_0-contours with the tank- and outfall-factors, m_0 and s_0, as inates. The curves are thus conveniently exhibited in terms of m_0, and D_0, from which solutions to problems may be quickly obtained. these curves others for intermediate values of H_0 and D_0 are readily by direct interpolation, since the curves given are openly and evenly . In the discussion and examples to follow, the diagram of Fig. 9, 1, will be referred to as " the field." The difference between H_0 $_0$, where the contours intersect, gives the depth of tank, Δ_0. One for $\Delta_0 = 0{\cdot}4$, is shown dotted. When considering problems in the depth of the tank is fixed, the derivation of solutions will be ated by drawing the appropriate Δ_0-curve on " the field."

plication. It remains now to consider some examples illustrating e of " the field " and, at the same time, to discuss some points which n the design of tanks and outfalls.

the following examples, the coefficient of friction f is taken as 0·01, lues of L are presumed to include for bends, valves, etc. All dimen- are in foot-second units and all heights are measured from mean vel.

ample 1. Given : $Q = 3{\cdot}0$, $H = 10{\cdot}3$, $A = 7500$, $R = 12{\cdot}0$, $L = 5500$, $T = 12$ hours 24 minutes.

To determine d and Δ.

$$H_0 = \frac{10{\cdot}3}{12{\cdot}0} = 0{\cdot}86 \text{ and } m = \frac{Q}{A} = 4{\cdot}0 \times 10^{-4},$$

and hence from equations (12):

$$m_0 = 4{\cdot}133 \times 10^{-4}.$$

By interpolation for the $H_0 = 0{\cdot}86$ contour, inspection of " the
shows that, for the given value of m_0:

$$s_0 = 0{\cdot}665 \text{ and } D_0 = 0{\cdot}37.$$

Transforming these results back, equations (12) give:

$$D = 4{\cdot}44 \text{ and } s = 2{\cdot}302.$$

Thus the required depth of tank is given by:

$$\Delta = H - D = 5{\cdot}86.$$

Using the relations:

$$sk = Q \text{ and } k = \pi\left(\frac{gd^5}{32fl}\right) \quad . \quad . \quad . \quad . \quad (13a) \text{ and } (1$$

it will be found that $d = 1{\cdot}566$.

With this value of d and the above data, a graphical solution is
by the " periodic z-curve " *IV*, Fig. 11, Plate 1 (see Appendix).
graphical solution gives $\Delta = 6{\cdot}1$ feet, which agrees within 4 per c
" the field " solution.

Example 2. Supposing d is fixed at a commercial size of pip
1·5, and with the data of example 1, it is requi
determine A and Δ.

From equation (13*b*), $k = 1{\cdot}17$.
From equation (13*a*), $s = 2{\cdot}563$.
From equations (12) $s_0 = 0{\cdot}739$.
From " the field " (using the curve for $H_0 = 0{\cdot}86$):

$$m_0 = 2{\cdot}45 \times 10^{-4} \text{ and } D_0 = 0{\cdot}615.$$

Hence, from equations (12):

$$m = 2{\cdot}373 \times 10^{-4},$$

whence $A = 12{,}640$, $D = 7{\cdot}38$ and $\Delta = 2{\cdot}92$.

Effect of change in R.

In the previous examples solutions have been obtained for on
only. In designing a scheme, however, it is essential to know what c
are produced in the tank-levels when the tides change in range from s
to neaps, to ensure that the scheme, as designed for one tide, is satisf
for any other tide. It will now be shown, by means of an exampl
" the field " may be used to determine these changes; no genera
clusion can be drawn, but it is important to note that any design sho
checked by the methods of the following example.

Example 3. In Table I values of R are given as obtained from an
tide-table in which the range ($2R$) varies from 47·83 to 32·5. By m

eld" a design is obtained for the spring tide, then with the known of A and d for this design, that is, with m and s fixed, it is possible, the field" and by transformation, to obtain H and D for each ive tide consequent upon the change in R.

$= 21{\cdot}55$, $Q = 8{\cdot}45$, $T = 12{\cdot}4$, $L = 5500$, and $d = 2{\cdot}0$.

e spring tide:

$$H_0 = 0{\cdot}9 \text{ (approximately) and } s_0 = 0{\cdot}717.$$

"the field":

$$m_0 = 3{\cdot}76 \times 10^{-4} \text{ and } D_0 = 11{\cdot}96.$$

results are shown in line 1, Table I.

TABLE I.

	s_0	$m_0 \times 10^{-4}$	H_0	D_0	H	D	Line.
5	0·717	3·760	0·900	0·500	21·55	11·96	1
35	0·718	3·780	0·900	0·502	21·40	11·94	2
00	0·723	3·825	0·914	0·508	21·50	11·98	3
25	0·729	3·885	0·928	0·520	21·45	12·00	4
40	0·738	3·990	0·943	0·535	21·15	12·08	5
00	0·748	4·080	0·964	0·550	21·20	12·10	6
50	0·758	4·230	0·979	0·560	20·80	11·90	7
15	0·766	4·300	0·993	0·570	20·75	11·93	8
25	0·782	4·470	1·020	0·600	20·50	12·08	9
40	0·789	4·550	1·030	0·607	20·30	11·97	10
00	0·804	4·730	1·053	0·635	20·00	12·06	11
80	0·822	4·975	1·083	0·655	19·55	11·85	12
80	0·838	5·110	1·105	0·675	19·45	11·85	13
50	0·843	5·210	1·116	0·680	19·25	11·73	14
00	0·863	5·450	1·148	0·709	18·95	11·69	15
50	0·870	5·530	1·158	0·723	18·80	11·74	16

dition:

$H - D = 9{\cdot}59$, $m = 7{\cdot}25$ 10, $A = 11650$, and $s = 3{\cdot}51$.

ing the above dimensions of tank and outfall, m and s are now for the next tide, $R = 23{\cdot}785$, transformations for m_0 and s_0 allow erivation of H_0 and D_0 from "the field." Further transformations H and D.

This process is repeated for successive tides, and the results sh the Table give the variation of maximum and minimum tank-level complete tide cycle. It should be noted, however, that the results the "periodic z-curve" and not for the continuous "z-curve." however, H and D change slowly from one tide to the next, the diff between the "periodic" and continuous "z-curves" will be sma for all practical purposes, the results may be accepted as representi true values of H and D.

In Table I, it will be seen that H decreases with R, and therefo tank, as designed for the spring tide, will not be completely filled other tide. For all values of R, D shows very little fluctuation; D is less than 11·96, the tank will empty some time before it begins up again. For some tides D exceeds 11·96, in which case the tank w completely empty itself on a tide, and the stored liquid will be forward to the next tide. In this example, the tank will not comp empty for a number of successive tides; the residue will, however small that for all practical purposes it may be neglected and the may be regarded as satisfactory.

If the scheme is designed for neap tides, $R = 16{\cdot}25$, it will be that $s_0 = 0{\cdot}8725$, $H_0 = 1{\cdot}327$, $m_0 = 10{\cdot}6 \times 10^{-4}$, $D_0 = 0{\cdot}545$, $A =$ $D = 8{\cdot}86$, and $\varDelta = 7{\cdot}39$. With this design, and deriving results f spring tides by the procedure explained above, it can be shown $H = 27{\cdot}10$ and $D = 7{\cdot}89$. It is thus evident that this design w quite inadequate to deal with the flow under spring-tide conditions

It is, of course, advisable to provide a margin of safety in c A convenient method is to increase d, for it can be shown, by refere "the field", that both H and D are decreased as required. On the hand, an increase in A is not satisfactory, because this leads to an in in D and the tank may not empty during each tide.

Most Economical Scheme. In each example considered, two of th factors m_0, s_0, H_0, D_0, have been fixed, and the remaining two d from "the field," which two, after transformation, provide a d solution to the problem. In most practical cases, however, only Q, L T, and H are known, and these quantities fix H_0 only in the abov factors. Since a solution can be found when any two factors are it follows that, fixing one only (for example, H_0), there are a large nu of possible solutions. Given a choice of solutions which will satis conditions of the problem, it is evident that the one to choose is th providing the most economical scheme.

In deriving solutions from "the field" for the given H_0-contour of values for m_0, s_0, and D_0 are obtained, which after transformation p corresponding values for A, D, and d. Having regard to practical r tions which may be imposed upon A, $\varDelta$, and d, and having ascertain the method of example 3 that the proposed schemes prove satisfacto the range of R between spring tides and neap tides, the procedure

is to determine the most economical scheme of those proposed by ng the cost of each one. As will be appreciated, costs are influenced conditions, and bear no simple relationship to A, d, L and Δ, so useful purpose is served if this theoretical discussion is extended to h a problem which introduces costs.

ough a complete solution to the particular problem of the Paper n obtained, it is appreciated that many problems still remain. In t place, "the field" will allow a thorough analysis to be made arly with a view to finding general conclusions on the subject of d on the effect of variation of the tank-, outfall-, and tide-factors. re, again, problems such as are given by a variation in Q, prohibited of discharge, and cases where the end of the outfall is above low-vel, all of which it is proposed to consider in future research.

ACKNOWLEDGEMENTS.

Author wishes to thank the Engineering Faculty of Liverpool ity for permission to carry out experiments in their hydraulic ory, and for a grant from their Pacific Steam Navigation Research owards the cost of the apparatus.

Author is also deeply indebted to Dr. A. G. Walker of the Pure hatics Department, Liverpool University, for his help and advice more mathematical part of this work.

Paper is accompanied by nine sheets of drawings, from some of Plate 1 and the Figures in the text have been prepared, and by owing Appendix.

APPENDIX.

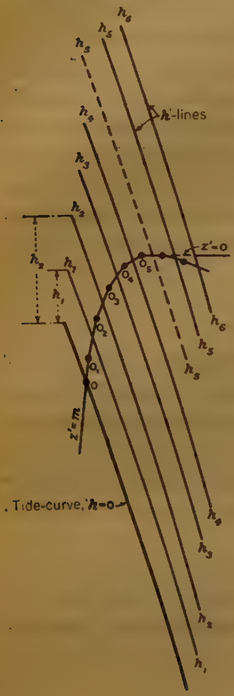
aphical method of obtaining the "z-curve." Writing z' for dz/dt, equation (3) :

$$z' = m - \alpha\sqrt{h} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14)$$

ich it is seen that, for fixed values of m and α, the slope of the "z-curve" is or all positive values of h; when h is negative $z' = m$. Hence, as shown in (p. 236), by drawing a similar set of tide curves to the original one, but at heights $h_1, h_2, \ldots h_s, \ldots h_5$, etc. above it, the value of z' is known where curve" cuts these lines, which will be hereafter referred to as "h-lines." the slopes derived from equation (14) for lines $h_1, h_2, \ldots, h_s, \ldots h_5$, etc. sented by $z_1', z_2', \ldots z_s', \ldots z_5'$, etc. The graphical construction of the e" is as follows. First the h-lines are drawn vertically above the tide curves *Fig. 10*), as mentioned above. Then, starting at any point such as o_2, midway the "h_1-" and "h_2-lines," a line is drawn at a slope z_2' to o_3, which is a point between the "h_2-" and "h_3-lines." Similarly o_4, the point midway between nd h_4- lines can be found, by drawing a line at slope z_3' from o_3 to o_4. Repeating struction, the whole "z-curve" may be derived, the points o_1 and o being

found by inverse construction from o_2. In *Fig. 10*, the "z-curve" is shown t
tide curve; the construction is quite general, however, and holds for cases w
always positive and for any shape of tide curve.

Fig. 10.

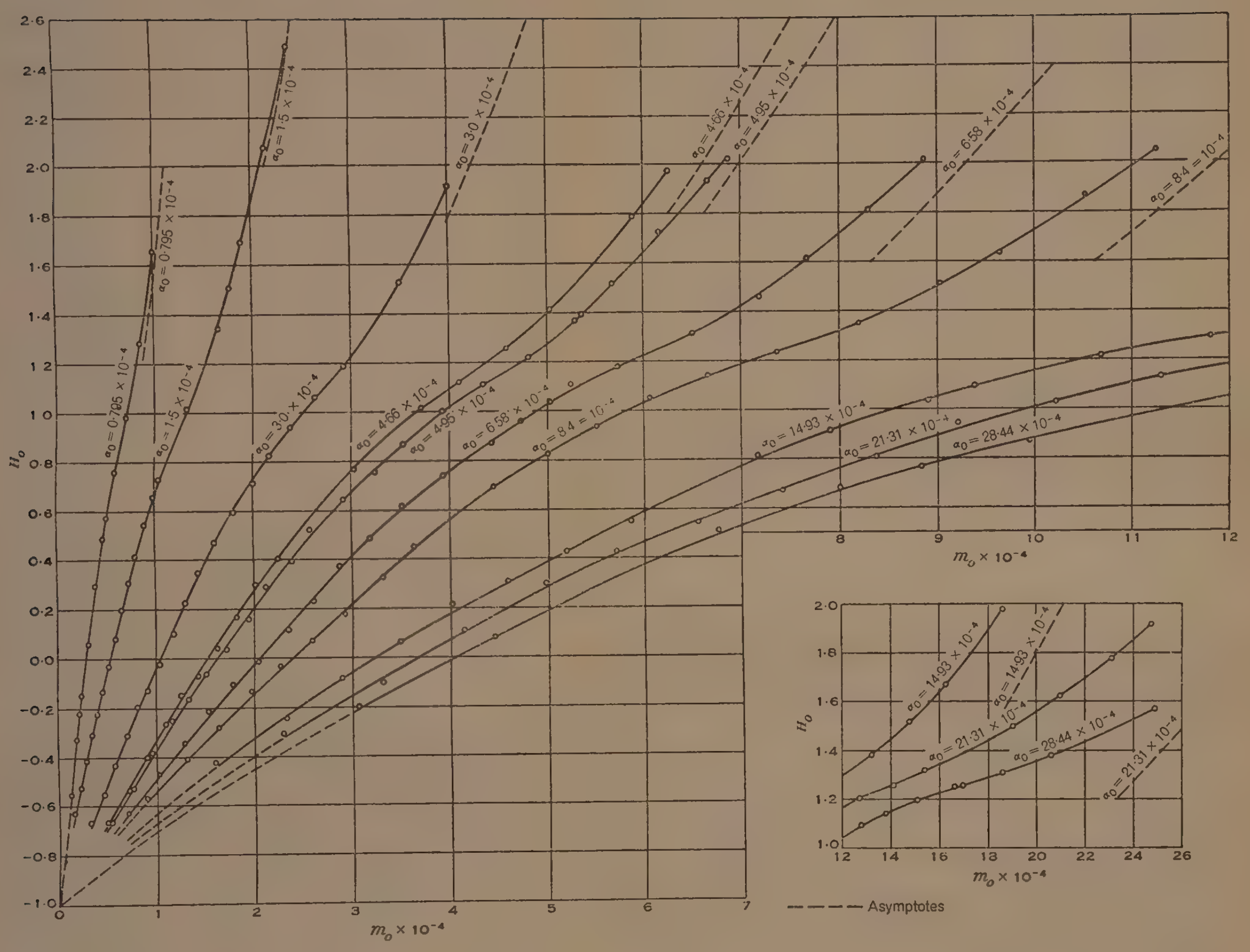


At $h = 0$, $z' = m$, the z curve cuts the tide
slope m. When $h = \frac{m^2}{\alpha^2} = s^2$, $z' = 0$, and the "z
is a maximum or minimum; this h-line is s
h_s and dotted in *Fig. 10*. When h is less than
positive and when h is greater than h_s, z' is
Writing $h = z - \zeta$, $d^2z/dt^2 = z''$, $d/dt = \zeta'$, and
tiating (14), it is seen that $z'' = 0$ when $z' = \zeta'$,
at the point of inflexion, it is theoretically impo
derive the "z-curve" graphically, since there is
section with the "h-lines." When $z' = 0$, howe
"z-curve" has small curvature, and if the "
are drawn close together in the region of inflex
"z-curves" may be projected through this reg
reasonable accuracy. To make *Fig. 10* clear, on
"h-lines" are shown. It will be realized, of cou
the closer together these lines are drawn, th
accurate will the results be.

A series of "z-curves", obtained graphically f
tide curve, and numbered I, II, III, and IV, ar
in Fig. 11, Plate 1. The values essential to the c
tion are: $R = 1{\cdot}0$, $T = 248$, $m = 0{\cdot}006$, α
in foot-second units. The "h- lines" are drawn
foot intervals, and with this ratio of the interv
the "z-curves" are practically coincident w
derived tangents. The curves I, II, and III ha
drawn continuous, each one beginning on the ti
at a point where the preceding one finished. C
begins and finishes on the tide curve for the sam
of z and is thus a "periodic z-curve." This
used to provide a check on solutions obtained fr
field." (See example I, p. 231.)

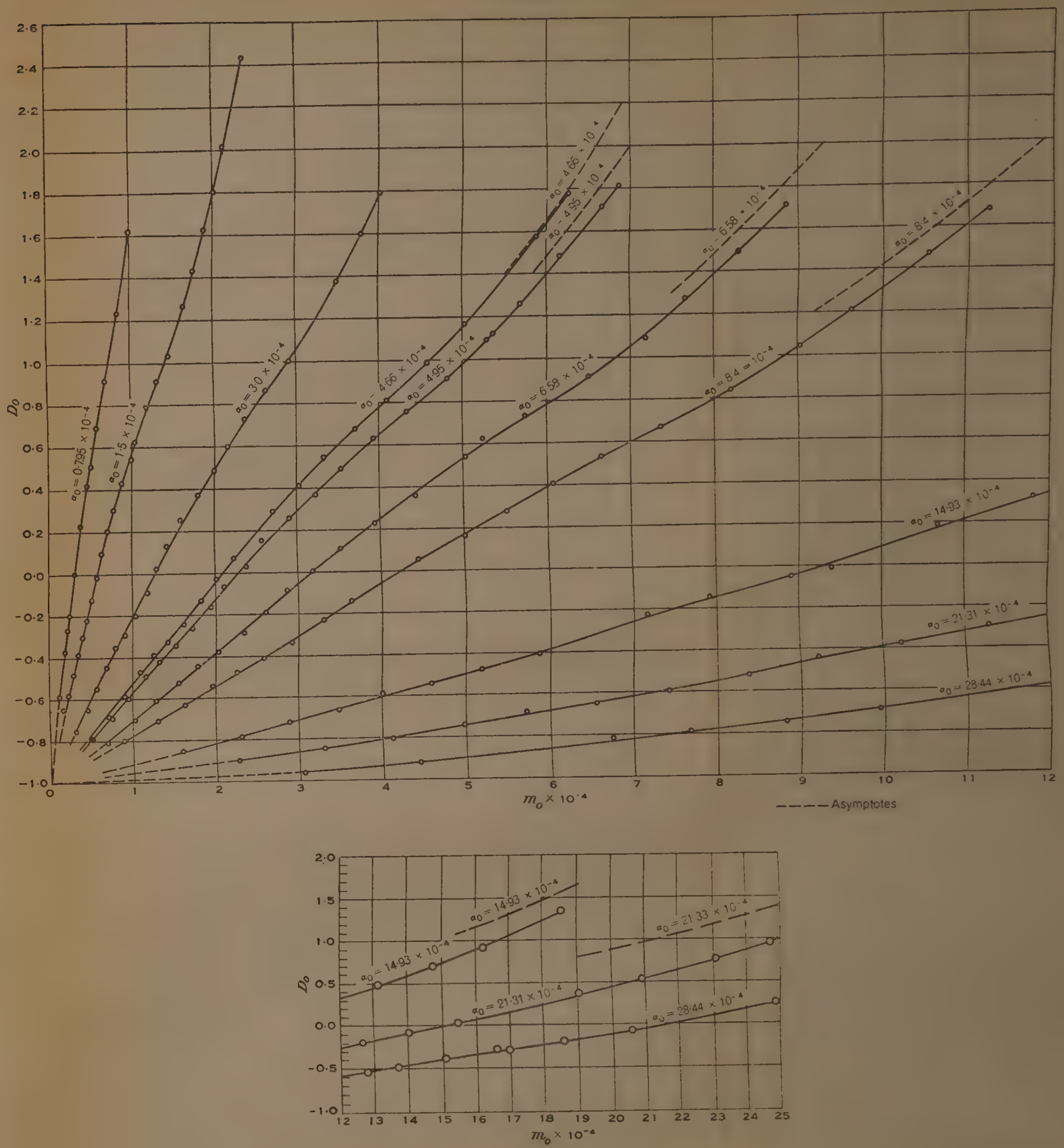
Since the graphical construction permits
curve" to be started on any "h-line", it is e
convenient to start on the "h_5-line" when che
"field" solution for H and D. The check ma
wards be completed by constructing the remainder of the "z-curve" to verify
it is a "periodic z-curve" or not.

FIGS: 4.



"α_o-CONSTANT" CURVES FOR H_o

FIGS: 5.



"α_o-CONSTANT" CURVES FOR D_o

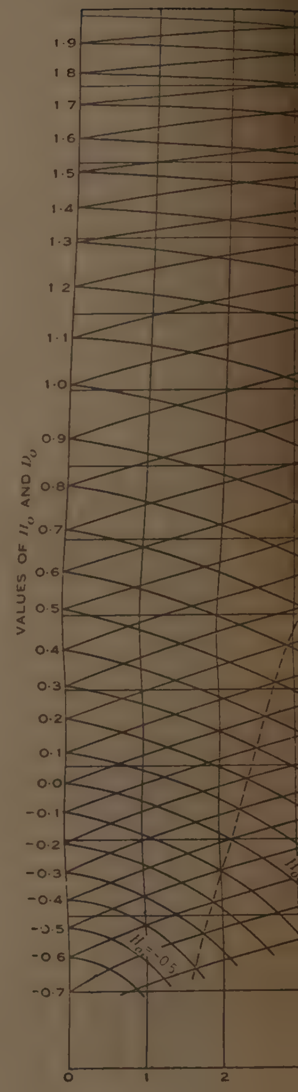
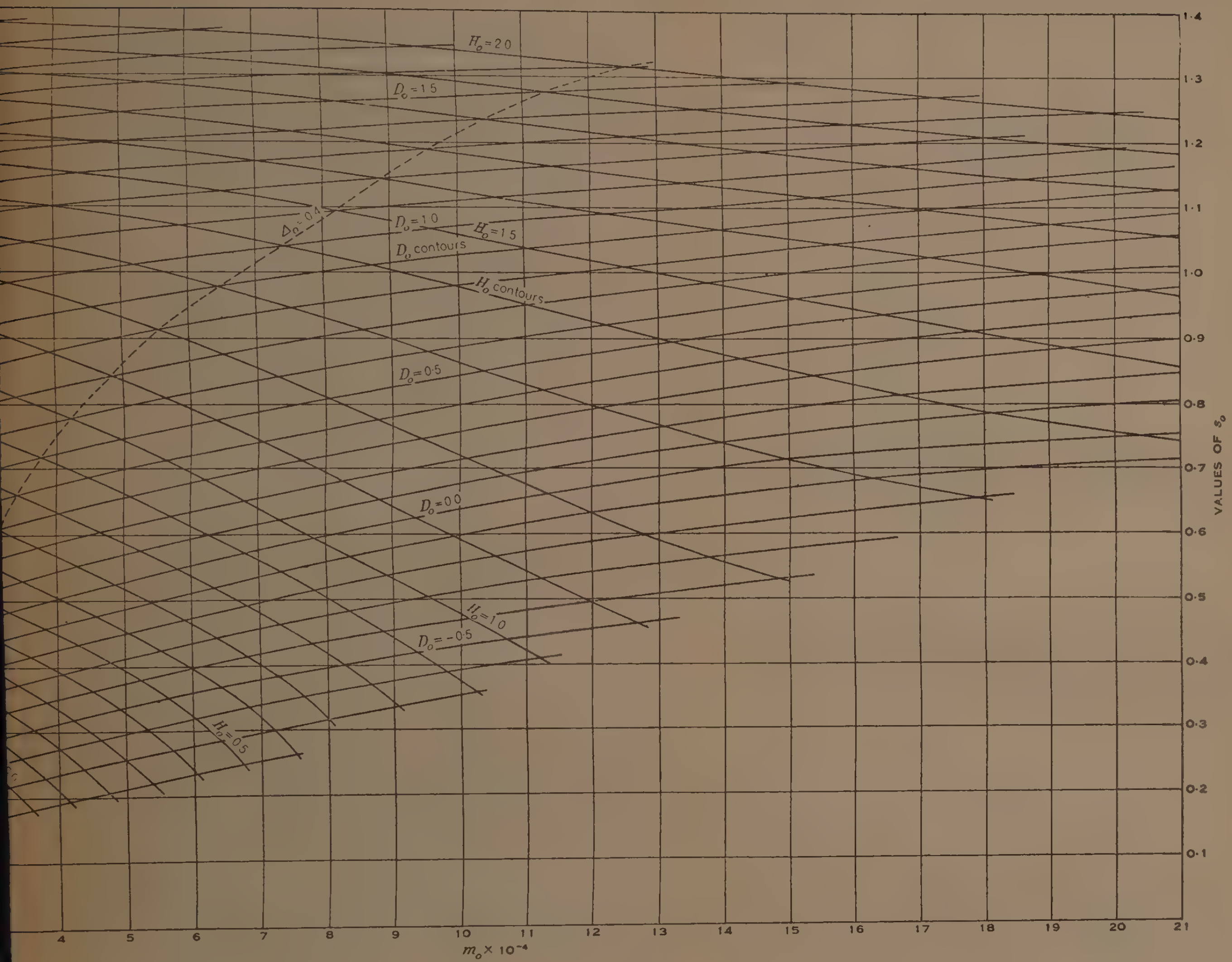
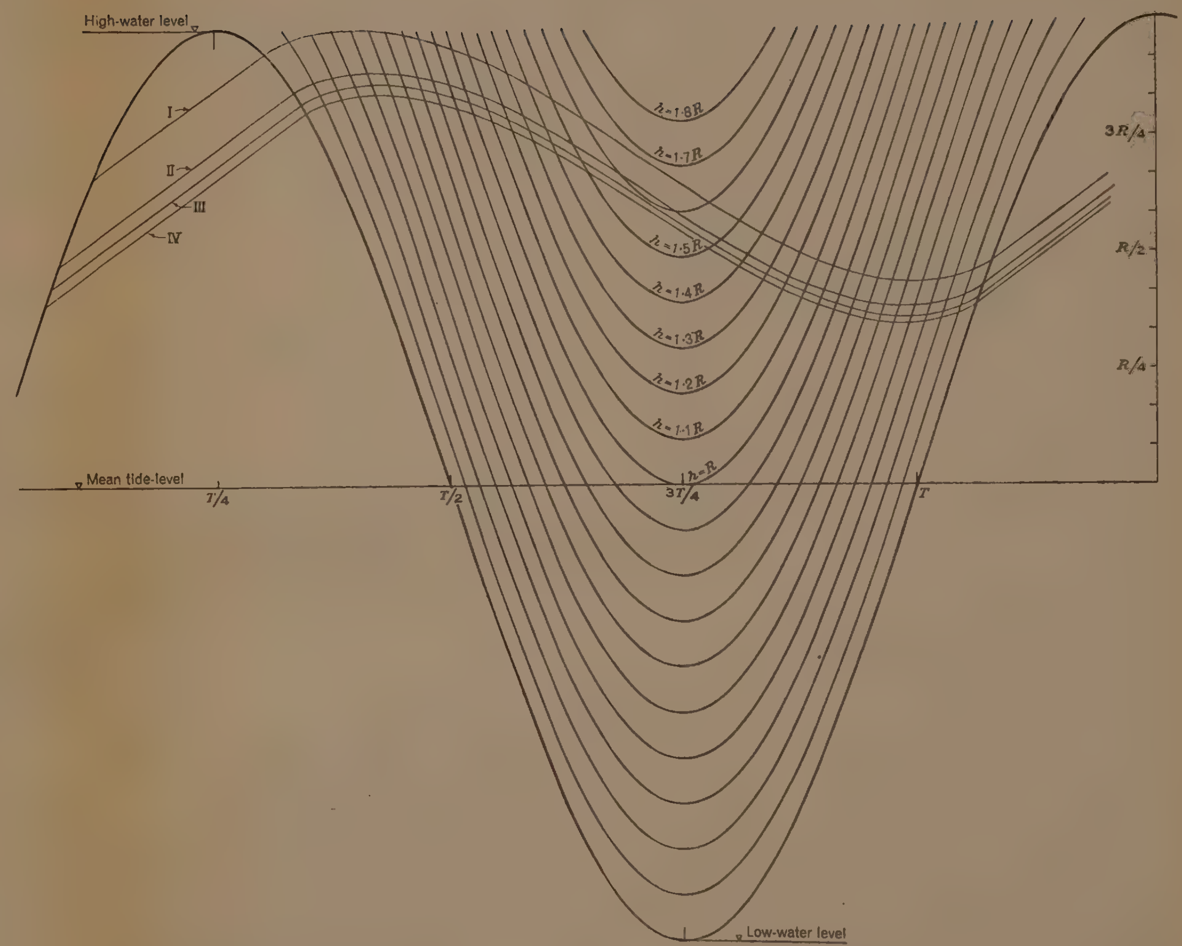


FIG: 9.



"THE FIELD"

FIG: 11.



TYPICAL "z-CURVES" (I, II, AND III), AND PERIODIC "z-CURVE" (IV)

J. R. DAYMOND.

Paper No. 5220.

"The Kidlington Bridges."

By Isaac Kursbatt, B.Sc., Assoc. M. Inst. C.E.

rdered by the Council to be published with written discussion.)[1]

TABLE OF CONTENTS.

Introduction.

ject of the Paper is to describe the works carried out by the Oxford- ounty Council on the Oxford–Banbury road (A.423) at Kidlington, s approximately 6 miles from Oxford.

merly the road was carried over the Great Western Railway (Oxford– gham branch), by a three-span skew bridge consisting of a central rder span of 37 feet and two side brick-arch spans of 18 feet 5 inches. up" and "down" lines are connected by a crossing under the girder span, the north arch accommodating a loop for goods traffic. uth arch span was never used. The brick-arched structure was bout the year 1840, but records are not available. In 1925 the cast-iron arched-girder span was replaced by steel plate-girders ted by concrete-backed brick jack-arches, the carriageway being d at the same time for the increase of road traffic which was then nt.

out 350 feet north of this point, the road was carried over the Oxford– gham Canal by a stone-arch bridge built in 1788, which was widened east side about 1845 with three flat-arched cast-iron girders spanned -iron troughing. There was a sharp S-bend in the roadway between idges and a steep gradient on the south approach to the canal with a cottage on its north side obscuring the view in a southerly

[1] rrespondence on this Paper can be accepted until the 15th May, 1940, and will ished in the Institution Journal for October, 1940.—Sec. Inst. C.E.

direction. The junction of Langford lane, which connects the H road with the Woodstock road (A.42), emerged on the north side sharp bend. This junction, therefore, was extremely dangero was the scene of a number of fatal accidents.

Census figures show that traffic on this section of the road has in by 78 per cent. since 1931, and it was essential to effect an impro Fig. 1, Plate 1, shows the plan of the old road with the new work imposed.

Considerations Affecting the Design.

It will be seen from Fig. 1, Plate 1, that re-alignment of the r was of primary importance. Two reverse curves of approx 3,000 feet radius joined by a short straight were found to be suita linking-up with the existing road at the extremities, the entire le the diversion being 1,600 feet. All further considerations were quently based on this line.

Originally allowance was made for a formation of 50 feet, a approximate position of the railway bridge was fixed. Considerati then given to the possibility of widening the existing bridge o sides, but the complications introduced by the crossing previousl tioned made it necessary to carry out extensive alterations to th and signals in order to extend the pier on the north side, and to m the required clearances from the track. Since the inconvenience a comparatively large expenditure necessary to effect these alteratio out of proportion to the magnitude of the scheme, it was agreed w Railway Company to close the opening to the south arch and repl remaining two openings by a single skew span of 79 feet 8 inches o three tracks, the square span being 49 feet 6 inches.

The final level of the crown of the road on this bridge was the d factor in determining the gradients of both road-approaches, and quently the gradients of the accommodation roads. It was, the necessary to keep the constructional depth down to an absolute mi Previous experience in the county indicated that a fixed-ended frame type of bridge would best meet the requirements. The gradient aimed at for the approaches was 1 in 30, with the standar bolic curve of 550 feet, giving a visibility of 500 feet at a hei 3 feet 9 inches. On the south approach this was possible, but on the approach the vertical curve had to be foreshortened slightly a gradient steepened to 1 in 27 in order to give agreeable gradients railway-station approach and the accommodation road to the r hotel and the farm beyond.

Referring to the site plan, it will be seen that the new line of th made an extremely acute angle with the old canal, so acute, in fac it was impracticable to build a bridge with the canal in this p

angles of skew were investigated in order to estimate the minimum d cost of bridge and canal-diversion. This analysis showed that of 45 degrees was most economical.

he crown of the road was now fixed by the gradient and its position anal-diversion, also the fairway clearances by the Canal Company, nly a question of the type of bridge which would suit the require- of available constructional depth. The consideration of various structures resulted in the arched steel portal frame being adopted. nation works which formed a comparatively large monetary item cheme were reduced to a minimum. The width of the formation mately increased to 60 feet to allow for a 30-foot carriageway, s, and cycle-tracks.

Borings.

mber of trial holes were opened out on the site of the new railway and in each case cornbrash was found at approximately 5 feet il-level, which is 211·00 O.D. On the site of the canal bridge the taken indicated the cornbrash at 198·00 O.D. which is 12 feet below vel, the subsoil above this level being mainly sand.

Design.

Bridge.

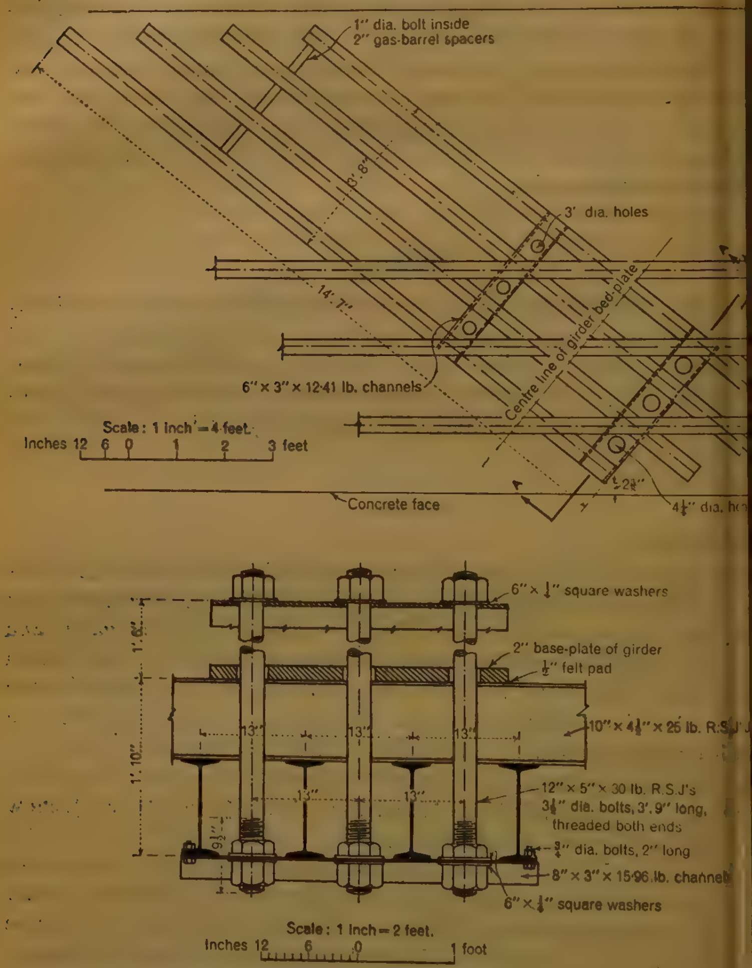
essential feature of the design was to obtain a suitable architecture nt with economy and small constructional depth. With that end , the soffit was curved to follow the railway-clearance gauge and cture was faced, where possible, with the local rubble-stone known ddies," with dressed quoins, string-course, and a coping of stone he Farmington quarries near Northleach, Gloucestershire. On ias of the girders, the concrete covering was made to match the gton stone with No. 2 cream "Colorcrete" cement, which will ribed later. Fig. 2, Plate 1, and *Figs. 3* and *4* (pp. 240–241), show eral details of the construction.

girders, which are at an angle of 38 degrees 59 minutes 40 seconds to of the abutment, have a span of 81 feet 4¼ inches between main and are spaced at 8-foot 9½-inch centres. The spacing of the cross ing frames is 5 feet 5 inches. Although the clearance allowed e highest rail-level is 14 feet 6 inches, a further 4 inches was added entral 65 feet of the girder to give some camber to the soffit. By ng 2 inches of camber to the top flange, the extra 4 inches rise to it was partially counteracted. The depth over the flange-plates at wn is 2 feet 9¾ inches, which is $\frac{1}{29}$ of the clear span.

the design stage it seemed likely that the bridge would have onstructed in two sections to allow for the maintenance of a road

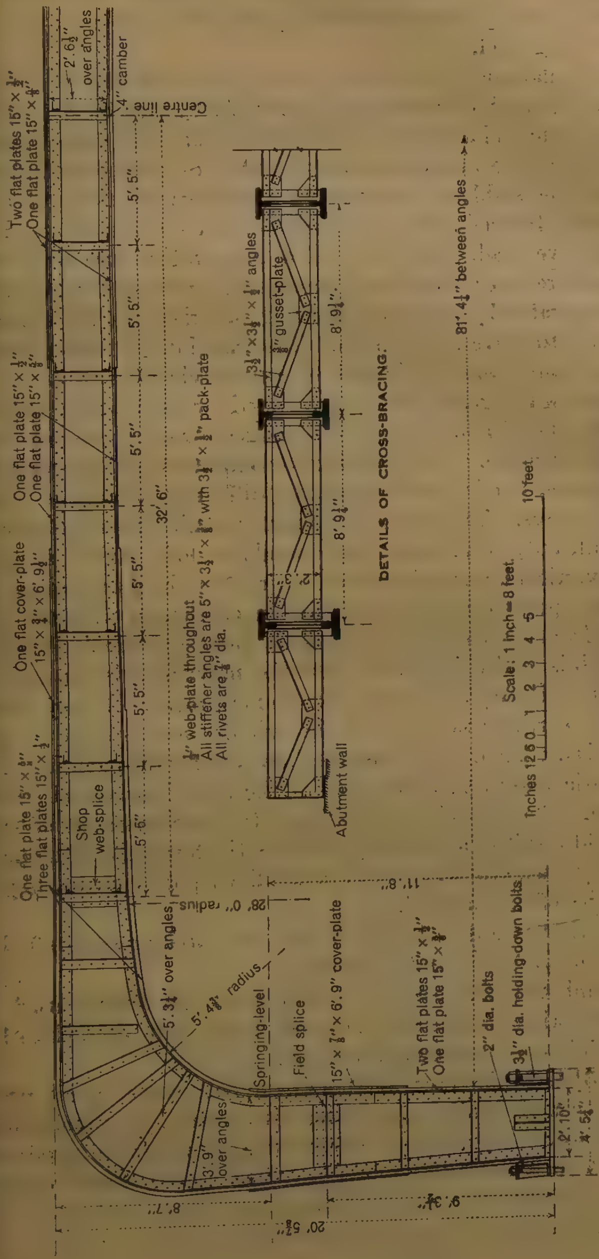
traffic route; it was important, therefore, that the design should for that contingency. The working stresses in the deck slab were per square inch compression in concrete, and 16,000 lb. per squar

Figs. 3.



tension in steel, the former corresponding to the 3 : 1½ : 1 grade of co allowed by the Ministry of Transport. By arranging the main st span between the cross-frames and the distributing steel between girders, it was possible to build a portion of the bridge and avoi overhanging transversely, which might hamper the erection of an ad girder. The overall depth of the slab is 8 inches, allowing for 1

Figs. 4.



DETAILS OF GIRDERS FOR RAILWAY BRIDGE.

minimum cover over the reinforcement, the latter consisting of diameter bars at 5½-inch centres, with ½-inch diameter bars at 7-inch as distributing steel.

The calculations for the fixed-ended portal followed, with sligh fications, the method developed by Mr. A. G. Hayden[1]. This which is a practical adaptation of Mohr's theorem, enables the des obtain a complete analysis of any number of points around the from which he is able to compute the scantlings necessary for all s Account was taken in these computations of dead load and Min Transport live load, together with a temperature rise or fall of Earth-pressure effects were not considered, since the vertical lir entirely separated by expansion-jointing material from the abutme and are free to move inside them. The omission of earth-pressure in portal frames was considered to have decided advantages ge and with skew bridges in particular. Earth-pressure acting at the b the abutments of monolithic skew bridges forms a twisting mon the entire structure. It is possible to compute some approximate for the couple, but it would be rather difficult to translate the e terms of stresses. The torsional moments would probably affect t most of all, but, in addition, there would be longitudinal shearing along the vertical limbs which would be greatest along the points of f

Another point deserving mention in connexion with the usu of portal frame is the effect of passive earth-pressure. When th zontal limb is loaded it deflects, and the movement is transmitted vertical limbs if they are free to take up movement. If they are res by passive earth-pressure, then the original assumption of con flexibility is modified. It is possible, however, for the back-filling to as an elastic mass and allow part of the small horizontal movem take place. The restraint thus offered to the movement of the limbs would result in a tendency to make the horizontal limb act e an ordinary encastré beam or as a modified portal frame, depend the elasticity of the back-fill.

It was therefore decided to obviate the earth-pressure effects e by the method adopted in this design.

The combined effects of bending moment and direct thrust we in the calculations of the final stresses, which were limited to 9 to square inch in compression and tension.

Three 3½-inch-diameter holding-down bolts were found necess resist the eccentric loading at the base of the frame. To enable these b be centred accurately during construction, they were fixed rigidly by of cross-channels and locking nuts to 12-inch by 5-inch steel joists sp in the direction of the main girders, with a layer of 10-inch by 4 steel joists parallel to the face of the abutment (*Fig. 4*, p. 241). The

[1] "The Rigid Frame Bridge." Chapman & Hall, Ltd., London, 1931

sed in a concrete abutment 10 feet wide by 3 feet deep. Partly on purposes, and partly to allow for the possibility of a reversal nt at the base, three 2-inch-diameter bolts were allowed on the ion side.

splice-joints were arranged near the points of inflexion in the l limb, and field-splices just below the springing points of the ich correspond approximately to the points of inflexion in the imbs. To obviate maintenance costs, the girders are encased in The minimum cover to the soffit flanges is 2 inches and the a 3-inch covering on either side. Panels are formed between on the horizontal limbs. The flat soffit-curve made it possible ge for all these panels to be identical, thus giving the contractor rtunity to re-use panel-shutter units.

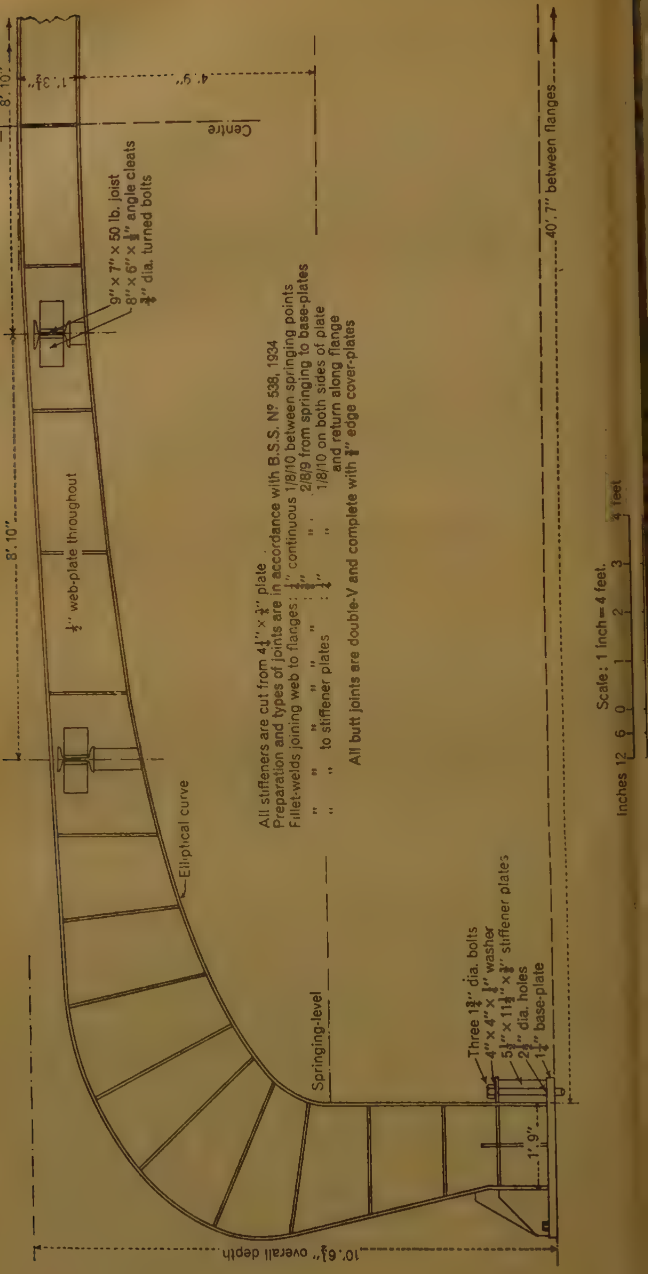
deck slab is of uniform thickness throughout and conforms on rside to the camber and longitudinal curve of the roadway. It proofed with a $\frac{3}{4}$-inch layer of natural-rock asphalt, and a 2-inch nastic asphalt with 1-inch granite chippings forms the final running

etaining- and abutment-walls are in mass concrete.

ridge.

design of this bridge was in many respects similar to that of the rail-dge with the exception of detail (*Fig. 5*, p. 244). In the previous case als were riveted and built up in three sections, but in the canal hey are electrically welded throughout and are complete units. The rve is elliptical and the span between flanges is 40 feet 7 inches overall depth at the crown of 1 foot $3\frac{1}{2}$ inches, giving a crown-)-span ratio of 1 to 30·5. Four continuous $\frac{1}{4}$-inch fillet welds connect -plate to the flanges on the horizontal limb and the size of the fillet increased to $\frac{3}{8}$ inch on both legs down to the point of fixation on of the increased shear stresses. Butt joints, staggered on intrados rados flanges, are at the approximate points of inflexion. The height of the girders was governed by considerations of transport, Railway Company were consulted during the course of design. to the 1-in-27 gradient of the roadway and the 45-degree angle of was found that the west parapet would be 2 feet 4 inches higher e east parapet. The eight girder-seatings were, therefore, raised essive steps of 4 inches, the lowest girder when encased in concrete he minimum fairway clearances, and the cross-girder seatings were l accordingly. In that way it was possible to present similar ns on either side. Each cross-girder had to be designed for different levels, lengths, and connexions owing to the contributary effects , extrados profile, and the 4-inch stepping up of the main portals, oducing the effect shown in cross-section YY, Figs. 6, Plate 1.

Fig. 5.



8' 10"
1' 3½"
4' 9"
Centre line
9" × 7" × 50 lb. joist
8" × 6" × ½" angle cleats
⅞" dia. turned bolts
½" web-plate throughout
8' 10"
Elliptical curve
All stiffeners are cut from 4½" × ½" plate
Preparation and types of joints are in accordance with B.S.S. Nº 538, 1934
Fillet-welds joining web to flanges: ½" continuous 1/8/10 between springing points
" " " " : ⅝" " 2/8/9 from springing to base-plates
" " to stiffener plates : ½" " 1/8/10 on both sides of plate and return along flange
All butt joints are double-V and complete with ⅜" edge cover-plates
Springing-level
Three 1⅞" dia. bolts
4" × 4" × ½" washer
5½" × 11½" × ⅜" stiffener plates
2¼" dia. holes
1½" base-plate
1' 9"
10' 6½" overall depth
40' 7" between flanges
Scale: 1 Inch = 4 feet.
Inches 12 6 0 1 2 3 4 feet

:ados profile could have been made to suit the gradient of the , but it was ruled out owing to assymetry and the unnecessary tions in the calculations. Instead, only one side follows the and the other is made up in concrete.

concrete encasement of the bases above water-level made them $7\frac{1}{4}$ inches in front of the faces of the abutments. If that were to ed, the span would have had to be increased by 1 foot $2\frac{1}{2}$ inches. re, therefore, embodied as an architectural feature in the form of ns from the abutment faces.

leck slab was designed for a maximum stress of 750 lb. per square npression in concrete. Advantage was taken of the 45-degree gle creating square bays of 8 feet 10 inches, thus allowing the nding moment to be equally divided in directions parallel to and angles to the main girders, giving a two-way reinforcing system a-diameter bars at $5\frac{1}{2}$-inch centres with an overall slab thickness es.

el grillage below the bases of the frames was not considered neces- account of the light loading. The holding-down bolts are, there- bedded to a sufficient depth in the abutment to enable a stress of). per square inch to be developed at the theoretical points of fixa- ight steel templates of welded construction position the lower these bolts which are threaded to receive locking nuts.

iversion.

wall of the new diversion was to be formed by 9-foot sheets of ed-concrete piling of 15-inch by 5-inch section and capped with a by 1-foot 10-inch cast-in-situ concrete coping, the tops of the former oken off to expose the reinforcement, which would bond with the The coping is tied back to 3-foot by 1-foot 6-inch by 2-foot concrete y means of 1-inch-diameter bolts at 8-foot intervals. The bottom version was to be puddled with clay to ensure watertightness.

on and Roadworks.

filling for embankments was specified to be gravel and would sup- temporary roadway 26 feet wide, consisting of 9-inch hand-laid -stone well rolled and blinded with gravel which, in turn, would -inch coating of crushed stone rendered watertight by two separate cold emulsion blinded with $\frac{3}{8}$-inch clean shingle. The final surface crete haunching would be completed at a later date to enable the ment to take up most of its settlement.

CONSTRUCTION.

Railway Bridge.

The contractors decided to build this bridge in two sections i of using a temporary bridge. The superposition of the site of the ne the existing bridge was such that three portal girders could be on the east face when the latter was partially demolished, leaving a single-way traffic route and a 4-foot footpath.

Demolition of this section of the existing structure started on th May, 1937, one-way traffic being directed by a manually-operate In the meantime, the adjacent mass-concrete wing-walls were pa built up. Owing to the Railway Company's request that not mor 8 feet of the excavations adjacent to the track should be opened any particular time, concreting to the abutment foundations had carried out by the hit-and-miss method. This restriction involv contractors in some difficulties with the fixing of the steel grillage a holding-down bolts. Lozenge-shaped frames consisting of 6-inch by timbers bolted together and 7-inch by 2-inch runners supported the e tions, and allowed the lower members of the grillage which run to the spandrel face-line to be threaded in position. No great quan water was encountered and what did appear was amply dealt wit 2-inch centrifugal self-priming pump. As will be imagined, the frames slipped slightly during the removal of the struts when th joists were threaded through them, with the result that great car to be exercised in keeping the excavations safe. Fortunately, f second half of the structure, the Railway Company agreed to op the entire excavations for the foundations, using 12-inch by 6-inch walings and struts with 9-inch by 3-inch runners. The preca taken by the Railway Company, however, seemed justifiable si speed restrictions were placed on the "down" line, and fast pas traffic set up appreciable vibration near the excavations. Ac positioning of the holding-down bolts was simplified by the te and the $\frac{3}{4}$-inch clearances in the holes of the grillage channels. The mum allowable error between centres of $3\frac{1}{2}$-inch-diameter bolts was The grade of concrete for the encasement was 4 : 2 : 1, local $\frac{3}{4}$-inch gravel and sand being used. Throughout the contract the cemen measured by weight, on the basis of a density of 90 lb. per cubi The mixing was arranged so that one bag of cement was used fo batch in the hopper.

Three steel portal frames were erected on Sunday, 11 July. were fabricated at Chepstow and were transported by rail to th handling and placing being effected by the Railway Company's mobile crane. After the legs were set up and accurately space crane took the lift of the horizontal limb, and, travelling a short di with its load, landed the splice-joints in position. The nuts fo

-down bolts were not tightened down until the splices were riveted. erage time-interval between the actual lift from the truck and the ary bolting-up of the joint was 20 minutes. During the following ne cross-frames were bolted to the horizontal limbs and the splices veted. Concreting then proceeded and the vertical limbs were l to a depth of 6 feet. 1-inch bitumen-covered cork expansion- g was then fixed to the back of the girder and bitumen-coated paper sides. The abutment wall was then built up 3 feet. Throughout k, the encasement of the legs was kept 3 feet ahead of the abutment e.

ing the concreting of the decking slab, levels were taken at the of the girders. The maximum deflexion on the intermediate was $\frac{3}{16}$ inch.

ffic was diverted over the new bridge on the 2nd November, 1 having been allowed for the decking concrete to mature. Demoli- rted immediately on the remainder of the old bridge. It is interest- note that the old brick retaining walls which were battered at 1 in 8 und to be 2 feet thick at the base and retained a depth of 16 feet of The abutments of the skew arch consisted of a series of brick forts (founded on a 2-feet-deep raft of lime concrete) parallel to the el face, and supported a series of small arches spanning between them springing level of the main arch. Two brick-courses corbelled out alf-way down the inside of the walls for no apparent reason. Demoli- the main arch was carried out during a week-end occupation of ds loop, and obviated the necessity for centering and lagging as ginally intended.

underside of the girders and deck slab was finally sprayed with two e coats of "Callendure" black bitumen paint as a protection engine blast. Tests carried out with this paint on 6-inch concrete howed that it would not peel off after being subjected to prolonged ensive steam blasts.

the 30th June, 1938, the bridge was ready for normal traffic. The of 13 months taken for the construction would have been appre- reduced had it not been for the delay in obtaining the structural rk occasioned by the shortage. *Fig. 7* (facing p. 248) gives a view finished structure.

Bridge.

entire south abutment and wing-walls were built in one operation, order to maintain the normal canal traffic, it was possible to build alf of the north abutment. This, in turn, was governed by the size e provided by the contractor. The type used was a $3\frac{1}{2}$-ton electric onverted to steam power, and it had a 70-feet jib. Its short radius limited its usefulness since the site did not adapt itself to the travel

type, and it was dismantled and re-erected in three different positi stationary crane before the work was finally completed.

On the east half of the south abutment no difficulty was expo since the cornbrash was found at the expected levels and the coo of side-groove steel sheet-piling was supported on the canal side ground. For the west half there was no support from the ground was not possible to support or tie back the steel sheets facing th Moreover, the rock shelved down to 196·50 O.D., which is more thar below water-level. The overlying ground for almost the full dep running sand, and driving with a No. 7 McKiernan Terry hamme produce barely a foot of penetration into the rock brash. Further a tion to these conditions was the surcharge of the crane on the emba at the back of the dam which assisted in producing subsidence ground between it and the back steel piles, whilst excavation near t tom was in progress. It was therefore decided to excavate and c in sections of about 20-foot lengths, and to bulkhead these sectio light steel sheet-piling to prevent the continuous percolation of the sand into the working dam. Even with these precautions the always the danger of a blow-out, and the possibility of the coll the dam between the period of preparing the foundation and plac concrete.

The original borings proved very misleading for the foundation north abutment. No cornbrash was found at the expected lev subsequent borings inside the dam revealed a depth of 3 feet of fi clay at 190·00 O.D. overlying what was thought to be rock. The gro the full depth above the clay consisted of waterlogged sand. In driv steel cofferdam no indication was given of the subsoil conditions, si piles were driven practically to refusal when about 13 feet below level. On excavating, however, to within 8 feet below water- blow-out occurred, and the piles in that vicinity, which previous driven to refusal, were topped and re-driven, and they continued t comparatively easily for the next 3 feet. Several similar bl occurred at other points, and it was decided to top and re-drive all th piling to refusal. As an additional safeguard, the 9-foot rei concrete sheet-piles which were available from the canal diversi driven inside the dam in rows of three at 5-foot centres. These pil driven with a No. 6 McKiernan Terry hammer to a set of ¼ inch last fifty blows. Because of the compacting of the sand, the pen varied from 6½ feet to 3 feet. During driving, a 3-foot head of wa maintained in the dam as a precautionary measure. When the bott cleaned up, 12 feet below water-level, it was quite firm and satisfac

Concreting proceeded to the level of the underside of the holdin bolts. Welded-steel templets were fixed in position with the low of the bolts and additional temporary wooden templets were ne at the tops to hold them rigidly in position whilst concreting. Aft

RAILWAY BRIDGE AS COMPLETED.

Fig. 8.

; to the underside of the baseplates, all the steel piles were extracted he exception of the lower lengths around the north abutment and valls.

umber of visits were made to the steelworks during the fabrication welded portals and the usual tests from samples of the welder's vere satisfactory. There was, however, a variation in the span of rame, the minimum being ¼ inch greater than, and the maximum ı less than, the specified length of 40 feet 7 inches. On the site those were divided between both abutments to equalize the concrete over the faces of the legs and prevent straining at the cross-girder ions. Transportation of the steel frames from the railway station site was effected by means of an ordinary lorry specially adapted purpose.

erally, the building of the superstructure was similar to that of the bridge, with the exception of the support for the deck-slab. If the ork had been supported from girders above the finished work, ufficient overhead clearance would have had to be allowed to permit placing and screeding of the concrete. In this case the falsework pported from ⅝-inch-diameter bolts connected to 1-foot 6-inch by by ⅞-inch steel plates resting directly on the extrados flanges of the portals. The plates were left in the slab and the holes, left after g the shutters and withdrawing the bolts, were filled with 2 : 1 cement . By adopting this method all obstruction on top of the slab was ted. The 1-in-27 gradient, and the skew and camber of the roadway, er with the different levels of the cross-girders, made the encase-shuttering unusually complicated. At each intersection of main and cross-girder there were four different levels to the underside slab.

east half of the bridge was opened to traffic on the 30th June, he west half being completed during the following month. A view completed structure is given in *Fig. 8*.

Diversion.

reinforced-concrete sheet-piles which formed the wall of the on were cast on the works and were driven with a ½-ton diesel-type er.

subsoil conditions varied considerably and, where the ground was ely soft, this hammer gave good results. Where a gravelly subsoil countered, driving was extremely difficult and a 1¼-ton monkey was uted for the automatic hammer. The drop of the hammer in both vas 3 feet, and all the piles with the exception of about forty were to refusal.

a 160-foot section of the south bank there was an outcrop of the ash at water-level for a depth of 5 feet. Below this a hard solid

rock was struck, which, presumably, was the Forest Marble. Sinc driving was impossible, this section was supported by a mass concre 6 feet 6 inches high, vertical on the face and battered on the back, v in thickness from 1 foot 6 inches at the base to 10 inches at the to tied back to concrete blocks at 8-foot centres by means of 1-inch-di steel bars encased in 6 inches of concrete. No back-shutterin needed as the wall was well bonded back into the irregular stone fac

Where concrete piling could not be driven and the cost of a co wall was prohibitive, steel piling was substituted and tied back as The walls were capped with a 10-inch by 1-foot 10-inch reinforced-co curb projecting 10 inches above water-level.

The diversion, which varies in width from 20 feet to 32 feet 3 was excavated by a dragline to a depth of 6 feet below water-level. the excavations a dam was formed by light steel sheet-piling at the junction with the existing canal. A 6-inch centrifugal pump, togeth a small diaphragm pump, kept the diversion practically free from As previously mentioned, the subsoil conditions at the bottom of th canal varied from sand at the north end through clay and cornbr the centre to sand at the south end under the new bridge. It was ori intended to seal the bottom with puddle clay, but as an alternative agreed to spread bags of concrete in the form of stretchers in the with a slight overlap between successive bags. 3 days after this op was completed, a 200-foot length of the diversion was pumped dry leakage was detected during the following 2 days either in the b or the sides, the subsoil water providing a 3-foot 6-inch head. Th canal was then opened to traffic and part of the existing canal drag the required levels.

Formation and Roadworks.

Nearly 30,000 cubic yards of stone and gravel filling were brou the site from local borrow pits and consolidated in 1-foot layers lorries running over the work. Where the road crosses the old however, a sheepsfoot roller was used for consolidation. So far, in of the volume of heavy traffic, very little visible settlement has place. The roadworks were carried out by direct labour.

TESTS.

A large number of 6-inch concrete cubes were tested to destr and Table I shows the average figures for the crushing strengths in square inch.

The Building Research Station, Garston, on behalf of the Oxfor County Council, tested, at the steelworks, two welded-steel portals f

oridge. A complete description of the test is given by Messrs. J. J. ng and E. C. Redshaw [1].

TABLE I.

Grade.	7 days.	28 days.	3 months.
5 : 3 : 1	1,860	3,250	3,425
4 : 2 : 1	2.980	4,200	4,730
3 : 1½ : 1	3,675	5,290	5,620

is interesting to note that the results of these tests show very close nent with the values derived from theory for deflexion, outward , and stress. The knee was the only point where any appreciable nces were noted. The stress computation at the knee was originally on the straight-bar theory. On recalculation, using the curved-bar r, the deviation from the test results were considerably reduced.

COSTS.

e costs per square foot of opening were :

Railway bridge . . . . £2·46
Canal bridge . . . . £2·75

igher unit cost of the latter was in a large measure due to the extra ation work which was not originally anticipated.

ACKNOWLEDGEMENTS.

e design and the works were carried out under the direction of . T. Bennett, B.Sc., Assoc. M. Inst. C.E., County Surveyor, whom uthor wishes to thank for his permission to allow the publication is Paper. The Author also wishes to thank Mr. J. J. Leeming, Engineering Assistant to Mr. Bennett, for permission to reproduce of his photographs.

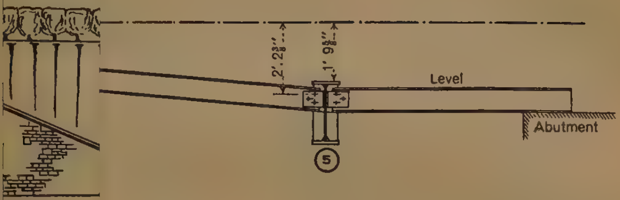
e Holborn Construction Company, Ltd., were the main contractors. sub-contractors for the structural steelwork were the Fairfield uilding and Engineering Company, Ltd. Mr. A. McColl acted as the actors' resident agent. The Author wishes to thank the engineers of reat Western Railway Company and the Oxford Canal Navigation any for their helpful co-operation during the progress of the works.

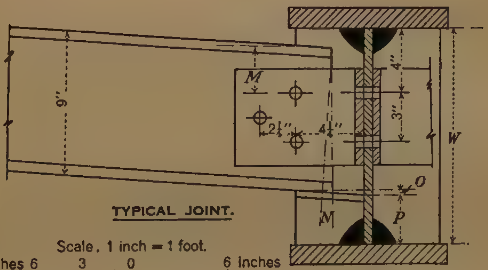
[1] "The Testing of Two Portal Frame Girders." Journal I. Struct. E., vol. xvii, (February 1939).

The Author assisted in the design and the preparation of the drawin
and also acted as resident engineer.

The Paper is accompanied by six sheets of drawings and eleven pho
graphs, from some of which Plate 1, the Figures in the text, and the ha
tone page-plate have been prepared.

PLATE 1.
THE KIDLINGTON BRIDGES.

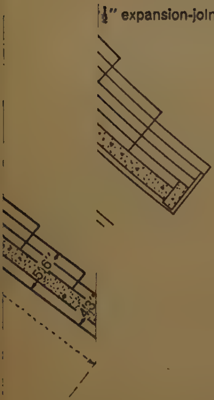




TYPICAL JOINT.

Scale. 1 inch = 1 foot.
Inches 6 3 0 6 Inches

Joint	Dimensions.				
	M	*N*	*O*	*P*	*W*
A_1	3"	⅜"	$-\frac{3}{16}$"	$3\frac{11}{16}$"	1'.1½"
A_2	3"	⅜"	$+\frac{3}{16}$"	$3\frac{5}{16}$"	1'.1½"
B_1	$2\frac{13}{16}$"	¾"	$-\frac{11}{32}$"	$3\frac{21}{32}$"	1'.1½"
B_2	$3\frac{3}{16}$"	¾"	$+\frac{11}{32}$"	$10\frac{31}{32}$"	1'.9⅛"
C_1	3"	$\frac{3}{64}$"	$+\frac{1}{32}$"	$11\frac{3}{32}$"	1'.9⅛"
C_2	3"	$\frac{3}{64}$"	$-\frac{1}{32}$"	$3\frac{7}{32}$"	1'.1½"
D	3"	0	0	11⅛"	1'.9⅛"



I. KURSBATT.

"Civil Engineering and Architecture."

By HARRY STUART GOODHART-RENDEL, P.P.R.I.B.A.

HEN I first used to read about architecture, the standard general history the subject in English was that written by James Fergusson[1]. At the ginning of this book came an attempt at distinguishing between archicture, civil engineering, and building, which even then did not seem to e successful. The distinction was boldly propounded, and was illustrated a woodcut showing a row of warehouses, that developed gradually from treme plainness on the left to considerable elaboration on the right[2]. At finite points in the row Building was supposed to give way to Civil ngineering and Civil Engineering to Architecture.

Fergusson was not a very sensible man, and this woodcut of his has ow only to be seen to be laughed at. The opinion it illustrated ought to em equally comical, and yet I wish I could be sure there were not many ople who still entertained it. The opinion was that architecture started hen the designer of a building tried to make a building look nice. Decency om the engineer perhaps, but Beauty from the architect.

Now, beauty is bred in the bone, and cannot be applied like powder d lipstick. There was not much beauty in any of Fergusson's wareuses, but I remember thinking—and I feel sure I still should think— at the plain one with which he began deteriorated progressively as he oled about with it. Its first state was rather bad and its last state was orse. Nothing can be well built upon a faulty foundation; to adorn ad engineering is only to add insult to injury.

The adornment of good engineering is another matter. Architectural lornment of all kinds is out of fashion to-day, and most young architects re convinced nudists. Few of their productions would have been condered by Fergusson or his contemporaries to be architecture at all. The est of them seem to me beautiful, but with a puritan beauty insufficient satisfy all the demands of civilized man. The demands of civilized man r something more are apt nowadays to be met with such things as the ower bridge, or the screen wall to the railway at Victoria, or the Battersea ower-station.

The Victoria screen is purely scenic, as a screen may legitimately be; ut my other two examples display arbitrary ideas of design that do not rise from the nature of the structure. The ideas at Battersea have pleased he public generally, those in the Tower bridge have not. Whether they

1 "The Illustrated Handbook of Architecture." London, 1855.

2 *Ibid*, vol. i, p. xxvii.

please or displease, such architecture, if something better than powder a lipstick, is still a beauty-shop affair—shall we say an example of plas surgery ? Its face is its fortune, and if a fickle public should tire of face it has nothing else to offer.

If the present war could lead to a complete re-union of civil engineeri with architecture, it would be worth carrying on for that end alone. think that it is bound to bring the two professions closer together, and mu depends upon what use we make of that proximity. They have not lo been separate ; indeed, it was only the last century that split into tw avocations what before had been but one. The schism has caused growi evils, and I am inclined to see no prosperous future for either until it healed.

Had Vauban been not one man, but an engineer with an architectur consultant or an architect with an engineering consultant, seventeent century France would almost certainly have got bad fortifications an barracks instead of good ones. Even in the eighteenth century you c find men equally at home in the designing of bridges and of churches : t excellent parish-church of Clapham is the work of a bridge-builder ; an it is only because he lived in the nineteenth century that the great Telfo showed himself at a disadvantage when a church came his way.

The separation of the professions might in itself be only a matter convenience if it did not inevitably result—if it had not already resulted in a separation of the things professed. Construction has tended become increasingly unarchitectural and architecture to become increa ingly unconstructional (despite the mysticism of the functionalists) ways that spell doom to both. No educated man may ever yet have he that architecture is the art of making buildings beautiful and engineerin the art of making them stand up ; but this favourite delusion of the vulg will spread if architects and engineers take no steps to dispel it. Befo they can do anything about it they must be quite sure that they clear conceive their own proper functions. These in practice are indefinite a confused—let us try to establish them by reason.

Suppose that *A* the architect and *E* the engineer, having not yet fuse their personalities in the diphthong *Æ*, are nevertheless collaborating wi absolute equality in the design of a new city. They have before them necessary surveys and data and an adequate programme of requirement Both may be assumed to have made a special study of town planning, whi has obtained for them their commission. *A* takes a particular interest circulation and the siting of civic buildings, *E* takes a particular interest water-supply and subsoil, but each in discussing the special subject of th other proves that two heads are better than one.

All goes as merrily as a wedding bell until *A* in the exuberance of h heart proposes to hang the municipal offices over the car park on enormo cantilevers. Says *E* : "*Must* you do that ?" *A* asks why not. simply asks "*Why ?*" *A* says it looks functional and all the best peop

it abroad. *E* wants to know what is the matter with stanchions. replies that the job will look cleaner without them, and with a touch of dity adds that no doubt it would be much *easier* to do it with stanchions. nd much easier to pay for," retorts *E*. This troubles *A*, whose study engineering has not been particularly directed towards economy. h, well," he grumbles, "I suppose we must use stanchions if you tell the other way is pointlessly expensive." "It's part of my job to tell that," *E* says; and he is right.

Later on, however, *A* gets a little of his own back. General principles ay-out have been amicably agreed, and the time has come to make a tch plan showing the principal streets with their traffic circulation. as many more statistics in his head than *A* has, and feels that in this he ht to outshine him. Yet in the end the plan is chiefly *A*'s, *E* generously wing that although many of the ideas in it are his own *A* has known ter than he how to simplify them and knock them into shape. "Well," s *A*, "I spent most of my 5 years at school in learning how to plan— can't expect a thing like planning to come by nature."

When, therefore, the moment arrives for designing the buildings *E* leaves *A* questions of general disposition and arrangement. But he ought to p his eye very closely on *A* when the first sketch is in a state to be died. If *A* is wise he will leave this sketch as indefinite and fluid as sible and hand it over to *E* for comment and criticism. If *E* knows his it is very likely that he can suggest now some better structural skeleton n the one *A* has had in mind. This may involve a radical reconsidera- n of the plan as far as it has gone, but if that is not far *A* can settle down it without regret. Had the plan gone further the happy atmosphere of laboration between the partners would have soured to compromise. d compromise between engineering and architecture begets monsters hly discreditable to both parents.

All through the later working-out of the designs *A* will hide nothing m *E* nor *E* from *A*, but they will keep up a continuous consultation, in er that the work of neither may ever have to be cut about to suit that the other. If *A* is genial enough to allow any ornament, he will not it to throw it in at the end, but will stir it into the pudding during the king. If *E* says that it spoils the taste *A* ought to be very attentive to criticism. Ornament is provided by *A* to please not only his brother but the whole non-architectural public, for which *E* is probably a very d spokesman.

Now this collaboration between *A* and *E* is not only imaginary but is y far removed from such collaboration as there is between architects d engineers to-day. With the best will in the world, they are less apt collaborate than to compromise, and, where the will is not the best, npromise quickly degenerates into mutual appeasement. I believe the se of this to be simple. The young architect and the young engineer day are each extremely ignorant of what is the other one's job. The

young architect has learnt some elementary engineering, enough to preve his requiring impossibilities, but he has seldom any large comprehensi of the world in which his engineer brother lives and thinks. The you engineer has no better comprehension of the mental outlook of his broth the architect. In saying this I speak only of Great Britain where t mutual isolation is much greater than is common elsewhere. The e appears to me a challenge that must be met by those in both professio who are in charge of education.

The eventual combination of the two professions—or, as I should c it, the re-uniting of the sundered profession—may not yet be in sight. Ma may despair of it as impracticable, some may even think it undesirab Nobody, however, can doubt the desirability of establishing the close possible sympathy between the two professions as they stand. If curricu can be compared and educational methods debated with a view to closing dangerously widening breach, a great thing may be done for the nation, achievement consummated that would be almost worth a war.

ABSTRACTS OF THE CURRENT TECHNICAL LITERATURE OF ENGINEERING AND APPLIED SCIENCE.

ENGINEERING CONSTRUCTION.

Failure by Torsion. (**Rev. Univ. Min.*, 8th series, **15**, *501–511; ʼct. 1939.*)—The Author discusses failures by torsion which are not ccounted for by the hitherto adopted methods of calculation. Considera- ions arising from ordinary torsion stresses are already well understood, but he Author deals with the problem of failure by the torsion stresses arising ut of simple longitudinal compression. An exhaustive mathematical nalysis is presented.

The Carrying Capacity of Piles. J. L. Kerisel (**Ann. Ponts Chauss.*, 09-i, *579–633; May 1939*).—The Author treats the subject in great etail, commencing with a consideration of the static type of formulas from he theoretical standpoint of the formulas of Bénabencq and Dörr. The nsuing relationships between the resistance of piles and the characteristics f the material penetrated were investigated by means of circular-section netal piles driven into Nemours sand, which has an angle of repose varying etween 20 degrees and 47 degrees. The experimental data are tabulated a comprehensive manner. The effects of driving piles are illustrated by hotographs of model-experiments showing the distortions of material hich is coloured in alternate layers. The Author also discusses the ercussion formulas, which concern the driving of piles. He describes riefly experiments conducted in Malesherbes sand, and compares the heories expounded by Hiley, Crandell and Sprenger, and Hollandais. le points out that the experiments described were all carried out in a non- oherent powdery material, and summarizes the practical considerations rising from the characteristics of coherent material.

Notes.—An asterisk prefixed to a reference, thus **Rev. Univ. Min.*, denotes hat the article is illustrated.

The abbreviated titles of periodicals are those used in the "World List of Scientific Periodicals" (Oxford 1934).

Rapidly-Constructed Driven Cylinder Foundations. (**Engng. New Rec.*, 123, *541–543 ; 26 Oct. 1939.*)—To support the main piers of three lif bridges under construction over the Cuyahoga river at Cleveland, Ohi 30-inch steel cylinders are being driven 150 feet through soft ground t rock, being socketed into the rock and filled with concrete. For th heaviest loading (625 tons) a steel H-beam is set in the cylinder befo concreting, being centered at the top and hung free to ensure its verticalit Each pier foundation comprises six cylinders supplemented by ste batter piles and a steel sheet-pile enclosure. A complete pier foundatio was constructed in 4 weeks.

Tests on Concrete Masonry Units using Tamping and Vibratio Moulding Methods. K. F. Wendt and P. M. Woodworth (**J. Ame Concrete Inst.*, 11, *121–163 ; Nov. 1939*).—The Authors present the resul of a comprehensive series of tests on concrete masonry units made wi seven different aggregates: cinders, limestone, sand, gravel, and thr proprietary aggregates. Comparative data indicate the effects of tw different types of moulding—vibration and tamping—upon the co pressive strength, absorption, capillarity, specific weight, durabilit volume-change, and thermal expansion for each aggregate. Similar da are presented for variations in cement-content for each aggregate, an fourteen conclusions are drawn.

The Effect of the Addition of Finely-ground Inert Material to Con crete. Sir Robert Chapman and P. E. Olsen (**Trans. Instn. Engr Aust.*, 11, *263–278 ; Aug. 1939*).—In view of experience gained in th construction of the Mount Bold dam, South Australia, tests were made determine under what conditions the addition of fine inert material mortar or concrete might be advantageous. The material considere consisted of powder passing through a 200-mesh sieve. The investigatio included tensile and compression tests on cement and filler pastes, and f density and consistency of the mixtures; for contraction, consistenc porosity, resistance to abrasion, and contraction of mortar; and tests o concrete cylinders. The Authors conclude that fine inert material concrete, in the form of finely-ground quartzite or hard limestone rock, not detrimental to the strength of the concrete, so long as its quantity do not exceed that of cement, whilst its use results in improved workabilit higher strength, and greater economy. In both mortar and concret however, the addition of similar fine material to the sand increases th contraction. In all cases the addition of finely-divided clay results excessive contraction.

The Ladybower Reservoir, Derbyshire. (**Engineer, Lond.*, 16 *440–442 ; 3 Nov. 1939.*)—The reservoir, under construction for the Derwe Valley Water Board, will contain 5,000 to 6,000 million gallons of wate

he dam, an earthwork embankment with a clay-puddle core, is about 250 feet in length, with a maximum height of more than 140 feet above e river-bed. Details are given of the constructional work, of the dis- arge tunnels, and of the overflows, the design of which formed the subject model-tests at Manchester University. The reservoir is to be completed 1941.

The Construction of Underground Petrol-Tanks. (**Ossature Métall.*, *432–435 ; Oct. 1939.*)—Underground tanks for the storage of petrol esent the advantages of protection against aerial attack, diminution of sses by evaporation, and protection against corrosion. The Author scusses the design of completely and semi-buried tanks, the choice of e and of the metallic reinforcement, and the constructional details and sting of tanks of the "auto-stable" and "hydraulic-compensation" pes.

Fatigue Tests of Connexion-Angles. W. M. Wilson and J. V. ombe (**Bull. Univ. Illinois Eng. Expt. Stn. No. 317, 18 pp. ; 3 Oct. 1939*). The object of the tests was to determine the magnitude of the deflexion which the outstanding leg of a connexion-angle can be subjected many mes without failure of either the angle or the rivets. Nine similar ecimens were tested, each consisting of two central plates, four filler ates, four angles, and a spacer. The central plates had $1\frac{1}{16}$-inch holes at e ends for bolting the specimen to the pulling-heads of 200,000-lb. fatigue- sting machines, whereby an axial force was developed parallel to the ngitudinal axis of the stringer, ranging from zero to a maximum tension, ereby subjecting the outstanding legs of the connexion-angles to a oment that varied from zero to a maximum. The results are tabulated d plotted in curves.

Symmetrical Loading on Continuous Beams. E. Shepley (**Con- ete Constr. Engng.*, 34, *548–556 ; Oct. 1939*).—An analytical method is scribed which gives a rapid solution for the support moments of a con- nuous beam when all spans are prismatic (uniform cross-section from pport to support) and all loadings are symmetrical. Common types of mmetrical loading are tabulated, and examples are worked for beams ving various "degrees of fixity."

Square Sections of Reinforced Concrete under Thrust and Non- mmetrical Bending. Paul Andersen (**Bull. Univ. Minnesota Eng. xpt. Stn. No. 14 ; 19 pp. ; 12 Aug. 1939*).—The Author presents a rational alysis of square concrete sections subject to the action of a direct force d four bending moments. A number of diagrams are reproduced, which ill enable the structural designer to determine the stresses for the most mmon cases without the necessity for solution of equations. The results

are given of tests of twenty-four square sections of reinforced concr[illegible] loaded eccentrically in two directions. The Author concludes that t[illegible] formulas developed for non-symmetrical bending represent the act[illegible] stress-distribution with an accuracy equal to that of the convention[illegible] analysis of reinforced concrete.

Stockport's Air-raid Shelters. (**Surveyor, Lond.*, 96, *423–42[illegible]*; *17 Nov. 1939*.)—The shelters consist of ½ mile of tunnel, 30–40 feet bel[illegible] ground-level, 7 feet wide by 7 feet high, cut out of the red sandstone ro[illegible] the total length of the front main tunnel being about 800 feet. There [illegible] two main tunnels, which are connected with nineteen galleries, each 30–[illegible] feet in length. The shelters will accommodate at least 3,850 perso[illegible] The entrances are in main shopping streets. All precautions were tak[illegible] to prevent any effects due to blast, whilst the entrances were strengthen[illegible] by reinforced-concrete roofs. The shelters are lighted from the ma[illegible] supply, with stand-by emergency accumulator lamps. Ventilation [illegible] effected by a very strong natural air-current.

The Summit Avenue Bridge. C. W. Dunham (**Civ. Engng., N.*[illegible] 9, *639–642*; *Nov. 1939*).—The bridge, forming part of the New Jer[illegible] approach to the Lincoln vehicular tunnel, is a two-span cellular reinforce[illegible] concrete continuous structure, with clear spans of 35 feet 10 inch[illegible] spandrels about 5 feet deep faced with sawn granite, abutments faced wi[illegible] granite ashlar masonry, and 2-foot concrete parapets. Four differe[illegible] designs were considered before the cellular form of structure was adopte[illegible] These are discussed and the construction is described in detail.

Raising a Railway-Station Footbridge under Traffic Conditio[illegible] (**Rly. Age, Chicago*, 107, *615–618*; *21 Oct. 1939*.)—The passenger-stati[illegible] at Harrisburg, Pa., includes eight through tracks covered by two roo[illegible] formed of trusses of 90 feet span, spaced 20 feet apart centre to cent[illegible] and supported on three lines of steel columns, the centre line of whi[illegible] takes the reaction from the trusses on both sides. A footbridge exten[illegible] across the eight tracks and five platforms, with stairways to each platfo[illegible] from each side of the bridge. By disconnecting a section of the stati[illegible] structure over the bridge and raising it with the bridge, by the aid [illegible] graduated scales or gauges at the lifting jacks, the heightening operati[illegible] necessitated to obtain the additional clearance required for electrifi[illegible] operation of the railway was accomplished successfully without interru[illegible] tion to the use of the bridge. The operations are described in detail.

Coast and River Conservancy. Ernest Latham (**Engineerin[illegible]* 148, *571–575*; *24 Nov. 1939*).—The natural defence of the English coa[illegible] line depends primarily upon the movement of shingle and sand or oth[illegible] beach material, which is supplied by falls from crumbling cliffs of vario[illegible]

rmations. Where there is a coast-line of hard, igneous rock the question coast erosion hardly arises, and the parts of the coast which require tificial aid are therefore reduced to the crumbling cliff sections and the w-lying coastal lands or marshes below high-water level. The Author scusses various portions of the English coasts, and the directions of ovement of the beach material. He describes the defences at different ints, and emphasizes the danger of excessive removal of beach ballast d the necesity for co-ordination of coast-defence and river-conservancy orks as part of a comprehensive scheme.

The Calculation of Infiltration. J. Mandel (**Ann. Ponts Chauss.*, 9-*ii*, *57–110 ; July 1939*).—The Author states that a knowledge of the ow by infiltration in soils is of considerable importance in various practical oblems, such as the supply to wells or springs, the prediction of seepage, d its prevention by methods of staunching. He demonstrates that filtration problems present a perfect analogy, from the mathematical int of view, with other classic physical problems which have been oroughly investigated. This enables him to obtain, by simple trans-sitions, the solutions of several problems of infiltration.

The River Liffey Hydro-Electric Scheme. V. D. Harty (**Concrete nstr. Engng.*, 34, *581–588 ; Nov. 1939*).—The purpose of the works scribed is to supply additional electricity to the national system and to ovide a further water-supply for greater Dublin. The chief power-plant d dam are at Pollaphuca, whilst a subsidiary power-plant and dam are ing built 1½ mile downstream. The Pollaphuca dam, of the straight avity type, has a maximum height of 104 feet and a total length of 225 et, and will impound 5,300 million cubic feet of water. Descriptions are ven of the constructional work, the intake, the pressure-gallery, and the rge-tank. The power-station houses two vertical-spindle turbines, rect-coupled to two 15,000-kilowatt generators. The subsidiary station, Golden Falls, contains one vertical-spindle Francis turbine, direct-upled to a 4,000-kilowatt generator.

MECHANICAL ENGINEERING.

Circulating Water, Heat-Transmission, and Heat-Discharge in ondensing Plants. R. H. Parsons (**Engineer, Lond.*, 168, *499–501 ; 7 Nov. 1939*).—The Author emphasizes the lack of published information regard to the quantity of water which passes through the condensers in ower-station operation. Test data from a modern station indicate that bout 52 B.Th.U. were carried away by the circulating water for every 00 B.Th.U. liberated in the furnaces. He presents nomograms by means f which the quantity of circulating water passing through any condenser

at any time can be immediately ascertained, provided that the requis[ite] temperature-readings and the particulars of the condenser concerned a[re] available.

The Theory of Flexible Mountings for Internal-Combustion Engin[es]. C. E. Iliffe (**J. Instn. Auto. Engrs.*, 8, *77–107 ; Dec. 1939*).—The Auth[or] discusses vibratory disturbances in internal-combustion engines, includi[ng] gas-pressure effects and inertia effects, in single-cylinder and multi-cylind[er] engines. He considers in detail systems with one degree and with sever[al] degrees of freedom. He gives a formula expressing the stiffness, in poun[ds] per foot, of rubber mountings, and discusses the problem of vehicle-engi[ne] stability on the road. A worked example is given for a four-cylind[er] engine.

Development of the Kadenacy Principle. (**Oil Engine*, 7, *214–21[7] Nov. 1939*.)—The governing principle of Kadenacy's work is that, if hig[h]-pressure gases are suddenly released from a vessel by the rapid opening o[f a] suitable orifice, the discharge is not in the form of a steady flow, but is [in] the nature of an explosion ; this must be followed by an actual, or a virtua[l] drop in pressure in the vessel, and leads to the return of the discharg[ed] gases towards the vessel. These reactions, occurring in very short interva[ls] of time, give rise to mass movements at high velocity. Particulars a[re] given of the improvements in output and efficiency obtained with engin[es] in which the exhaust arrangements have been modified to suit th[e] principle.

The Ottawa Street Power-Station, Lansing, Michigan. (**Power*, 8[3], *588–592 ; Oct. 1939*.)—In this municipal power-station for electricity- an[d] steam-supply the tower housing the boiler plant is of about the height of [a] sixteen-story building, and no chimney is visible. The equipment includ[es] two 225-000-lb.-per-hour steam-generating units, with pulverized-fu[el] firing, superheat-control at operating conditions of 850 lb. per square inc[h] and 900° F., six-stage feed-water heating, air-preheaters and electrostat[ic] precipitators, hydraulic-coupling speed-control of auxiliaries, a tripl[e] boiler-feed pump for light loads, and two-stage by-product plant wit[h] evaporators to supply district heating steam. A feature of the 25,00[0]-kilowatt turbine-generator is its ability to carry overload up to 31,2[50] kilowatts at 0·8 power-factor by increasing hydrogen-pressure in th[e] generator-casing from the normal few ounces to about 9 lb. gauge-pressure.

A 1,500-R.P.M., 200-Kilowatt " House " Diesel Generating Se[t]. (**Oil Engine*, 7, *176–177 ; Oct. 1939*.)—A remotely-controlled emergenc[y] diesel generating set has been installed recently in the power-station o[f] the Reading Corporation, to provide energy when the current from th[e] "grid" is cut off and the stand-by steam generating plant is not in operation.

he power unit is an eight-cylinder engine with two banks of cylinders t at 60 degrees. The bore is 7 inches, the stroke $7\frac{3}{4}$ inches, and the 12-our rating at 1,500 revolutions per minute is 330 brake-horsepower.

Vertical-Shaft Generators: Some Problems and their Solutions. R. Sills (**Elect. Engng., N.Y.*, 58, *469–479; Nov. 1939*).—The Author scusses the energy-flow in a hydro-electric system, weight and its support a vertical generator, rotor construction, magnetic forces, natural equencies of vibration, thermal-expansion forces, the effect of the mech-ical design upon other characteristics of a machine, cooling, and the oblem of keeping oil out of the windings. Typical designs are illustrated.

The Selection and Application of High-Temperature Piping Material. H. Krieg and G. Sonderman (**J. Amer. Weld. Soc.*, 18, *697–701; ov. 1939*).—The advent of steam-pressures ranging up to 2,500 lb. per uare inch, and of temperatures up to 950° F., has rendered the selection d application of piping material a major problem in power-plant design. he Authors discuss in detail the requirements for satisfactory high-mperature piping, which include a low creep-rate to permit the use of a in-wall tube, a stable material resistant to internal change of structure d to external oxidation and corrosion, and good workability of the aterial, especially in welding and in making bends during fabrication. hey also discuss the welding of such piping to produce the requisite safety joint-strength, structurally as well as metallurgically, and enumerate e specifications adopted for pipe-joints at the Windsor plant of the Ohio ower Company, to indicate the exacting requirements under which the elding was performed.

Effects of Temperature upon the Mechanical Performance of otating Electrical Machinery. C. Lynn (*Elect. Engng., N.Y.*, 58, *Trans.), 514–517; Oct. 1939*).—The Author discusses in detail the effects temperature upon insulating parts of alternating- and direct-current achines, the influence of heat upon commutator copper, solder, carbon d carbon-graphite brushes, and oil-lubricated sleeve-bearings, and onsiders problems of expansion and contraction due to temperature-ariations.

Deformation of Turbo-Alternator Rotor Windings due to Tempera-ure-Rise. G. A. Juhlin (**J. Instn. Elect. Engrs.*, 85, *544–552; Oct. 939*).—The Author discusses the effect of temperature upon the degree deformation of different conductors throughout the depths of the slots, d demonstrates that a comparatively small increase in temperature-rise ay cause the deformation to become serious. He presents a graphical ethod for determining the effect of a given temperature-rise, and discusses he effects of various methods of applying excitation to a machine.

Quick-Acting Release Latches for Circuit-Breakers. C. Thumm (*Mech. Engng.*, N.Y., 61, *807–812; Nov. 1939*).—The Author discuss the principles upon which design is based and classifies the four typ into which latches can generally be divided as follows: (*a*) dead centr (2) over centre toggle; (3) over centre surface; and (4) magnet. Illu trations of each type are reproduced, and force-analyses of these und various conditions are presented. An evaluation of the performan characteristics of the various types is given in a Table.

An American Diesel-Hydraulic Shunting Locomotive. (*Rly. Mec Engr.*, 113, *385–386, 395; Oct. 1939.*)—The locomotive is of the 0-6-0 type with jackshaft drive. A six-cylinder four-stroke-cycle solid-injectio diesel engine is fitted, rated at 400 brake-horsepower at 900 revolutio per minute, and drives through a hydraulic torque-converter, a tw speed gear-box, and a reversing gear-box, through which runs the jacksha Constant engine-output for a given throttle-setting is converted aut matically into the varying combinations of locomotive speed and drivin wheel torque, by means of the hydraulic torque-converter, depending the load on the locomotive. On test the locomotive started, accelerate stalled, restarted, and held, a load of 300 tons on a gradient of 1 in 20.

The 130-tonne Crane of the French National Railways. Brea (*Rev. Gén. Chem.-de-Fer*, 58 (*ii*), *221–227; 1 Oct. 1939*).—The new cran delivered at the end of 1938, was designed to lift 130 tonnes at a radius 6·25 metres (20·5 feet) and 90 tonnes at a radius of 9·55 metres (32·4 feet the weight of the crane being distributed so as to avoid all risk of dangerou bending stresses: pivoting supports are therefore fitted, which are close during travelling and opened when heavy loads have to be lifted. Th crane is carried on two four-axle bogies, each 4·5 metres (14·76 feet) length, and 4·5 metres apart between the inner axles. The counterweigh is carried on a separate wagon.

Rolling-Stock Bearings and Lubrication Problems. R. C. Cas (*J. Instn. Loco. Engrs.*, 29, *708–766; Sept.–Oct. 1939*).—The Autho points out that problems of wear and heating require separate consideratio although they are generally allied in practice. The importance of th following points is emphasized: protection from contamination; regul and continuous feed of lubricant; characteristics of lubricant; an relation of bearing metals and lubricants to bearing pressures and speed He deals mainly with the steps taken to overcome the hot-axlebox proble on Indian locomotives.

The Control of Structures welded by the Oxy-Acetylene Proces E. Henrion (*Ann. Assoc. Ing. Gand.*, 29, *413–464; 1939*).—The Autho emphasizes the necessity for a strict control not only of the operation

lding, but also of the welded structure as a whole. He discusses in tail the bases of a preventive control, with the object of avoiding any perfection in the weld, and deals successively with the precautions to exercised before, during, and after the welding operations. He con- ers the application of autogenous welding by the oxy-acetylene flame a process of assembly by localized fusion.

The Arc-Welding and Gas-Cutting of High-Tensile Low-Alloy uctural Steels. T. B. Wilkinson and H. O'Neill (**J. & Proc. Instn. ech. Engrs.*, 141, *497–512 ; Oct. 1939*).—The Authors present data in gard to the composition and test values of typical high-tensile steels, d also the results of tests on metallic-arc-welded joints, and of laboratory ts made to determine the weldability of steel plate. They conclude at it is desirable to limit the carbon-content of the steel to 0·2 per cent., d that for single-run fillets the use of a relatively low welding-speed -6 inches per minute), with a fillet-size of not less than half the thickness the plate, yields the best results. They state that the cutting of these eels by gas tends to produce cut edges having hard surfaces of reduced ctility.

Welding in the Manufacture of Valves for High Pressures and mperatures. W. F. Crawford and L. H. Carr (**J. Amer. Weld. Soc.*, , *713–722 ; Nov. 1939*).—The Authors state that since the introduc- n of the electric-arc covered electrode and the development of oxy- etylene hard surfacing processes, welding has played an important part improving the design of many types of valves for widely-different kinds service. Numerous examples of these are illustrated, and the more dely used valve materials are tabulated, with their analyses and minimum ysical properties.

Welding of Rails on the Great Indian Penninsula Railway. S. M. asan (**Quarterly Tech. Bull., Rly. Board of India*, 5, *3–7 ; Oct. 1939*).— rticulars are given of the welding process and equipment, and of the st ; the work represents the first application of welding to track in dia.

Welding Tungsten Steels. W. Spraragen and G. E. Claussen *J. Amer. Weld. Soc.*, 18 (*Weld. Research Suppl.*), *430–436 ; Nov. 1939*).— ne Authors present a review of the literature, up to 1 July, 1937, covering e welding of plain tungsten steel, tungsten high-speed steel, low-chromium ngsten steels, and nickel-tungsten-chromium steels. A bibliography ntaining eighty-one references is appended.

A New Temperature-Entropy Chart for Dry Air. J. R. Finniecome *Mech. World*, 106, *455 ; 17 Nov. 1939*).—The chart reproduced has been

prepared for turbo-blowers, turbo-compressors, superchargers, boost and air-turbines, and for reciprocating compressors. The pressures ran from 8 lb. to 300 lb. per square inch absolute, and the temperatures fr zero to 340° F. The mean specific heat at a constant pressure is taken 0·241, and the gas-constant as 53·30; these values, when referred to metric units, agree with those generally accepted on the Continent, a with the "Report on Tabulating the Results of Heat-Engine Trials (1927 published by The Institution.

MINING ENGINEERING.

Measurements of Pressures on Underground Rock Colum (*Rept. Infmn. U.S. Bur. Min., No. 3470, 8–9; Sept. 1939*).—With the of a new technique for applying the sonic method of determining elastic constants of rocks, the modulus of elasticity of thirty-three ro specimens, including granite, limestone, marble, and sandstone, w determined within an accuracy of 1 per cent. It is concluded that wa velocity in these rocks increases rapidly with pressure to about one-fou to one-half of the crushing strength, after which it asymptotically approac a maximum. It was found that some rocks that have been subject to la pressures (about 50 per cent. of the breaking strength), receive a perman set that appreciably lowers the velocity of sound, and hence redu Young's modulus. Measurements of the velocity of sound in mine-pill under various loads were made by means of geophones.

Investigations on the Behaviour of Steel Support at the Coal-Fa J. Weissner (**Glückauf, 75, 829–836; 841–847; 14 and 21 Oct., 1939*). Experiments were carried out to determine the most effective method using steel props at the coal-face in order to control the ground-press arising as a result of excavation. The reciprocal reactions between t strata and the steel support were observed in separate areas of the sa mine employing different systems of longwall working. The results a plotted in curves, which serve as the basis for the discussion of possi means of improving the work performed by steel props.

Pillar Extraction in Witbank Coal-Mines, Transvaal. (**S. Afr. Min & Engng. J.*, 50, *215–216; 259–261; 21 and 28 Oct., 1939.*)—A system caving-in the surface of the ground has been developed by the Transv and Delagoa Bay collieries to meet the conditions peculiar to the Witba coalfields, wherein the deepest level at which mining is carried on is 1 feet. The system is based upon the assumption that if crushed coal fr either pillars or roof could be buried under a compact fall, whether of r or of soil, and practically all air were excluded from contact with t

ushed coal, it would not ignite. A detailed description of the seams and the application of the method is given, and its advantages are enu-erated.

Mechanical Loading at the Union Pacific Coal-Mine, Wyoming. A. Nolph (**Coal Age*, 44 (*11*), *39–41 ; Nov. 1939*).—The mine produces out 3 million tons of coal per annum, all of which is now loaded mech-ically, the total number of appliances, including scrapers, shaking con-yors, tub loaders, mobile loaders, and drag conveyors, amounting to 188. e Author describes the development of the system and the rules enforced r maintenance of the equipment, and gives the costs for labour and aterials.

Mine Ventilation Research. G. E. McElroy (*Rept. Infmn. U.S. ur. Min., No. 3470, 23–24 ; Sept. 1939*).—New data on pressure-losses at anges in area in airways are analysed and correlated with similar data eviously published. A new graphical method of determining natural aught effect upon mine ventilation systems is described. Experiments ve been undertaken in the testing adit to determine the most effective ape and size of fan-pipe discharge for mine and tunnel ventilation. reliminary analyses of the results indicate that the velocity-distribution llows a definite law and that the maximum velocity at any distance from e discharge can be predicted in terms of the average velocity and area discharge ; the shape has little effect upon velocity-distribution ; the panding discharge ends of flexible material (canvas pipe) are not practical cause the change of velocity develops a negative pressure at the rear of e expansion-piece, causing collapse.

The Underground Fire at the Consolidation Colliery in 1938. F. Luy-en (**Glückauf*, 75, *761–768; 9 Sept. 1939*).—The Author describes a mine e which extended to a large part of the workings of a mine in Germany, d discusses the results obtained with the various expedients resorted to attempts to control the fire. Liberal use was made of carbon dioxide solid, liquid, and gaseous form, as well as of nitrogen gas when supplies carbon dioxide failed. It was found that when breathing apparatus had be used for long periods the provision of spare apparatus at points dicated by a red light inspired the men with a feeling of confidence, as ell as contributing to the saving of lives. Exceptional difficulty was countered in the detection of methane in the presence of carbon dioxide, d only laboratory results could be relied upon. Owing to the imme-ate action required in the initial stage of the fire, stoppings were some-mes built without the necessary care, or in wrong places. Consequently, gher officers of the mine staff were placed in charge of this work, acting instructions in writing, when possible, accompanied by sketches.

An Investigation into the Permissible Load-Changing Capacity **Steel Wire Ropes for Hoisting, with Special Reference to Deep-Le** **Winding on the Witwatersrand Gold-Fields.** J. J. P. Dolan a W. G. Jackson (**J. S. Afr. Instn. Engrs.*, 38, *86–136 ; Nov. 1939*).—T objects of the investigation were to determine the stresses to which winding-rope is subjected during winding operations, and the effects such stressing ; to analyse test data from the Government mechani laboratory ; to examine practice in other mining centres ; and to anal the results of investigations made in Europe and America. The v detailed results are presented in Tables and curves ; the bulk of the inf mation was that gathered from experience on the Witwatersrand. T Authors present eighteen conclusions and make the following recommen tions : the capacity-factor method of determining rope breaking ld should be used ; a discard capacity factor of 8·5 should be adopted rock, persons, and material without differentiation ; a percentage reduct in rope-strength, if stipulated, should not exceed 10 per cent. ; au graphic load–extension diagrams should be supplied with each te piece, the proof resilience value of these being compared by the m engineer to determine the probable life of the rope. Revisions to t Mines and Works Regulations dealing with the choice and loading of ro are also suggested.

Practical Problems in Pit Headgears. (**Colliery Guard.*, 159, *6 625 ; 3 Nov. 1939.*)—The article deals with the design of pit headgears a the difficulties arising from the installation of machinery in which efficien has been sacrificed for the sake of initial economy. The size of rope dru is dealt with and a device for correcting severe rope angling, due to drum being of insufficient diameter, is described in detail. The arti also shows the various steps in design of A- or H-framed headgears wh these are to be constructed and put into commission without a long stoppa of pit working.

Pumping Against a 3,304-Foot Head in a Single Lift. E. Slack (**Engng. & Min. J.*, 140 (*10*), *29–31 ; Oct. 1939*).—In July 1937 air-conditioning plant was installed at the 3,600-foot level of the Magm copper-mine, Superior, Arizona, the return condenser water being return from the mine by the existing pumping system. The desirability of a n pumping system became apparent, and two new pumps have been install near No. 8 shaft, the main exhaust ventilating shaft for the west secti of the mine. These are $6\frac{1}{4}$-inch by 24-inch, centre-packed duplex doub acting horizon pumps, each of 600-gallons-per-minute capacity, design for 3,465 feet (1,500 lb.) head. They are connected to two 600-horsepow 2,200-volt, three-phase 25-cycle motors, running at 485 revolutions p minute, and fitted with flywheel and flexible coupling through herri bone gear reduction-gear driving the pumps at 48·5 revolutions p minute.

The Mineralogy and Treatment of Auriferous Rocks of the Black eef Series from the New Machavie Mine, South Africa. J. J. FRANKEL *J. Chem. Met. Min. Soc. S. Afr.*, 40, *115–126 ; Sept. 1939*).—The Black eef series contains carbonaceous material which affects gold extraction cyaniding. The Author's description is confined to data not previously iblished, from the metallurgical rather than the mineralogical point of ew. His experiments, which are described in detail, lead him to conclude at the treatment should consist of grinding and removal of free gold and me pyrite on corduroy tables, followed by flotation, fine grinding, and anidation of the flotation concentrates.

Determining the Particle-Sizes of Dust-Separator Products by means a new Photo-electric Method. K. GÖSELE (**Forschung Ing. Wes.*, 10, *5–245 ; Sept.–Oct. 1939*).—The method described enables the particle-ze of the dust present to be directly determined in the dust-carrying air elf. The basic principle of the method is to determine photo-electrically e subsidence of the dust-particles in an enclosed air-space. The dust nsity is determined by directing a ray of light at right angles through the r and measuring the so-called Tyndall light, laterally dispersed by the ist-particles. The particle size-distribution of the dust is determined om the photo-electric values by a simple method of calculation. The ithor states that the results observed agree closely with those found by icroscopical analysis of the subsided dust.

Investigations of Electrical Equipment, Safety-Lamps, and Gas-etectors for Safety. L. C. ILSLEY (**Infmn. Circ. U.S. Bur. Min. o. 7068 ; 13 pp. ; Sept. 1939*).—An account is given of the tests to which e following apparatus is subjected in conformity with the requirements of e U.S. Bureau of Mines " Schedules ": explosion-proof mine equip-ent; permissible electric cap-lamps; flame safety-lamps; portable ethane-detectors; permissible telephones and signalling devices; electric ine-lamps other than cap-lamps; single-shot blasting-units; and ultiple-shot blasting-units.

An Electrified Colliery. (**Elect. Rev.*, 125, *695–698 ; 1 Dec. 1939.*) -Four seams are worked at the Wern Tarw colliery, South Wales, two of hich are won from a pair of vertical shafts and the others from inclines iven from the surface. Detailed descriptions are given of the electrical stallations for main and subsidiary haulage, for pumping, for coal-ashing, and for surface transport. The power-consumption amounts to oout 200,000 kilowatt-hours per month. The supply is taken from the 3-kilovolt line of the South Wales Power Company, and is transformed own to 3,300 volts, being further reduced to 550 volts for the smaller achines.

Ore Reserves. J. H. FENNELL (**Bull. Instn. Min. Metall., 1 422, 52 pp.; 9 Nov. 1939*).—The Author observes that the total extracta ore in a metalliferous deposit may be defined as all the ore within t boundaries of the deposit which can be reached by development a extracted at a profit. The estimation of proved ore and prospective should be kept separate, but this causes difficulty, as the prospective ore directly related to the exposed ore and the quantities of prospective estimated are largely dependent upon the quantities of ore that have be developed. The Author treats the two classes of ore together. discusses the bases of ore estimation and the computation of ore reserv and presents operating results obtained at various American mines. two Appendixes the results of tonnage calculations by the longitudin area method and the cross-section method are tabulated, and the calcu tions for the mean assays of three series of widths, and assays resulting fro the sampling of development openings in a gold-mine, are recorded.

NOTE.—The Institution as a body is not responsible either for t statements made, or for the opinions expressed, in the Papers an Abstracts published.

MADE AND PRINTED IN GREAT BRITAIN BY WILLIAM CLOWES AND SONS, LIMITED, LONDON AND BECCLES.

NOTE.—*Pages* [1] *to* [8] *can be omitted when the Journal is bound in* *lume form.*

NOTICES

No. 3, 1939–40

JANUARY, 1940.

THE INSTITUTION OF CIVIL ENGINEERS.

MEETINGS, SESSION 1939–40.

ORDINARY MEETINGS.

Tuesday, 23 *January, at* 1.25 *p.m.*—Ballot for the election of new embers.

Tuesday, 20 *February.*—Ballot for the election of new members, llowed by an Informal Meeting. The time will be given in the February ournal.

INFORMAL MEETINGS.

An Informal Meeting will be held at 1.30 p.m. on Tuesday, 23 January. ight refreshments will be provided before the Meeting.

Subject.	Introducer.	Chairman.
Some Aspects of Engineering Civil Defence Works."	T. Peirson Frank, Member of Council.	Sir Clement D. M. Hindley, President.

A brief synopsis of the Introductory remarks may be obtained upon pplication to the Secretary.

An Informal Meeting will be held on Tuesday, 20 February. Details ill be given in the February Journal.

Further meetings, as arranged, will be announced in the Journal.

GENERAL ANNOUNCEMENTS.

SUBSCRIPTIONS.

Members and Students are reminded that subscriptions for 1940 we due on the 1st January, 1940. The present subscription rates are follows :—

	Class A. (London Area.)			Class B. (Elsewhere in British Isles.)			Class C. (Abroad.)		
	£	s.	d.	£	s.	d.	£	s.	d.
Members	6	6	0	4	4	0	3	13	6
,, (retired)	3	13	6	2	12	6	2	12	6
Associate Members	3	13	6	2	12	6	2	12	6
,, ,, (retired). . .	2	12	6	2	2	0	2	2	0
Associates	5	0	0	5	0	0	5	0	0
Students	2	0	0	1	10	0	1	10	0

The attention of members is drawn to the fact that any contributi to the Benevolent Fund may be included in the cheque drawn in pa ment of the Institution subscription.

THE JOURNAL.

The remaining publication dates of the Journal for Session 1939–40 a the 15th February, March, April, June, and October, 1940.

READING ROOMS AND LIBRARY.

The Reading Rooms and Library are open during normal office hours s daylight. An air-raid shelter accommodating some 50 persons is availab for members who may be on business in the building during an air raid an for the Institution Staff.

The normal loan service of books from the Library is also availab for the use of members.

ELECTION, ADMISSION, AND EXAMINATIONS.

Copies of the Forms required in connexion with proposals for Electi to Corporate Membership, recommendations for Admission to Studentshi and by Students for entry for the Associate Membership Examinatio may be obtained on application to the Secretary, who will be pleased at times to deal with enquiries on these matters.

Students who wish to enter for the April, 1940, Associate Membersh Examination at home, which is to be held from the 15th to the 19t inclusive, of that month, are reminded that their completed applicatio to attend should be in the Secretary's hands by the 14th February.

CHARLES HAWKSLEY PRIZE.

The following subjects have been set for the competition to be adjudged March, 1940 :—

A combined underground garage and air-raid shelter.

A water-tower.

The Prize, of the value of £150, is awarded for the best design of an gineering structure combining artistic merit with excellence of construcnal design. Students and Associate Members under 30 years of age are gible to compete, and full particulars regarding the competition, with ails of the subjects set, may be obtained from the Secretary.

Designs must be submitted to the Secretary by the 29th February, 40.

C. C. LINDSAY CIVIL ENGINEERING SCHOLARSHIPS.

Regulations for the award of these Scholarships, sanctioned by the ard of Education, may be obtained on application to the Honorary cretary of the Glasgow and District Association, Mr. William MacGregor, Sc., Assoc. M. Inst. C.E., Engineering Department, The University, asgow, W.2. Eligibility for the award of these scholarships, which are ch of the value of not less than £25 per annum, is confined to Students The Institution who are members of the Glasgow and District Association of The Institution and are British subjects of Scottish parentage.

TRANSFERS, ELECTIONS, AND ADMISSIONS.

Since the 21st November, 1939, the following elections have taken place :

Meeting.	*Member.*	*Associate Members.*
19 Dec.	1	36

d during the same period the Council have transferred six Associate embers to the class of Members, and have admitted eighty-two Students.

DEATHS AND RESIGNATIONS.

The Council have received, with regret, intimation of the following aths and resignations :—

DEATHS.

OWNING, George Elliot. (E. 1893. T. 1903.)	*Member.*
EMENTS, Francis William. (E. 1914.)	,,
NNING, William John. (E. 1926.)	,,
REDAY, Harry John. (E. 1927.)	,,
NTER, Gilbert Macintyre. (E. 1888. T. 1912.)	,,
Touche, James Norman Digues. (E. 1902.)	,,
CHOLSON, *Sir* John Rumney, C.M.G. (E. 1897. T. 1903.)	,,
ELLSHEAR, Walter. (E. 1882. T. 1892.)	,,
ORTHINGTON, William Barton, D.Sc., B.Sc. (E. 1880. T. 1884.) *Past-President.*)	,,
YATT, James William, F.C.H. (E. 1883. T. 1906.)	,,
PLAND, George Dyson. (E. 1915.)	*Associate Member.*
DLER, William Henry. (E. 1918.)	,, ,,
TT, Lorenzo, C.M.G. (E. 1887.)	,, ,,
FF, George Andrew Middlemiss. (E. 1891.)	,, ,,
IG DE LA BELLACASA Y SAUCHEZ, Narciso. (E. 1893.)	,, ,,
ITH, John Michael James. (E. 1915.)	,, ,,

RESIGNATIONS.

BERRY, Charles Seager. (E. 1910. T. 1914.)	*Member.*
BOOTHBY, Basil Tanfield Beridge. (E. 1904. T. 1914.)	,,
BRADLEY, Godfrey Thomas. (E. 1912.)	,,
LACEY, Ernest Matthew. (E. 1893. T. 1899.)	,,
LAWTON, Harold, F.C.H. (E. 1932.)	,,
ROTHERA, *Sir* Percy, O.B.E. (E. 1910.)	,,
TAYLOR, Lionel Percy Duncuft, O.B.E. (E. 1911.)	,,
WHITLEY, Henry Stuart Beville. (E. 1921.)	,,
WILMSHURST, Thomas Percival, M.B.E. (E. 1927.)	,,
AMAN, Frederick Theodor. (E. 1897.)	*Associate Member.*
ANTHONY, Adam Charles Eric. (E. 1919.)	,, ,,
BOND, Herbert Ivo. (E. 1905.)	,, ,,
CAMERON, Arthur. (E. 1901.)	,, ,,
CARMICHAEL, John Samuel, B.A., B.E. (E. 1920.)	,, ,,
DILLEY, Wilfrid Joseph, B.Sc. (E. 1900.)	,, ,,
DUNCAN, Harry. (E. 1907.)	,, ,,
FADELLE, Joseph Edward. (E. 1904.)	,, ,,
GEEN, George Purdon, M.C. (E. 1910.)	,, ,,
GRAY, George David, B.A.I. (E. 1896.)	,, ,,
GRIFFIN, Noel Henry Rose. (E. 1908.)	,, ,,
HAIGH, William Henry. (E. 1902.)	,, ,,
HUBBARD, Alexander Egerton. (E. 1920.)	,, ,,
LYONS, Henry Montagu. (E. 1926.)	,, ,,
OKELL, Cyril. (E. 1918.)	,, ,,
PINCOMBE, William Edwin. (E. 1896.)	,, ,,
ROYLE, Frederick Murray. (E. 1897.)	,, ,,
SMITH, Alan Carrick. (E. 1921.)	,, ,,
SOUTHEY, Frederick. (E. 1900.)	,, ,,
STURGEON, Henry Curran. (E. 1913.)	,, ,,
WARREN, William Walter. (E. 1908.)	,, ,,
WOLSELEY-LEWIS, Frank Thomas. (E. 1899.)	,, ,,
HENRICI, *Major* Ernst Olaf, R.E. (ret.). (E. 1908.)	*Associate.*
HARVEY, William Arthur Henwood, B.A. (A. 1937.)	*Student.*
PARTRIDGE, Thomas Michael. (A. 1936.)	,,
TAMBE, Ram Vasudeo, B.Sc. (A. 1936.)	,,

RECENT ADDITIONS TO THE LIBRARY.

[Journals, Proceedings of Societies, British Standard Specifications, etc., are not included.]

AIR-DEFENCE. Statutory Rules and Orders, No. 920, 1939. "Air-Raid Shelters Revised Code." 1939. (H.M.S.O.) 6*d*.

ANGLES. WILSON, W. M., and J. V. COOMBE. "Fatigue Tests of Connection Angles." 1939. Illinois University Engineering Experiment Station Bulletin, Seri[es] No. 31. (Urbana.) 30 cents.

AUTOMOBILES. SCHIELDROP, E.B. "The Highway." 1939. (Hutchinson.) 5*s*.

In the second of the Author's series of four books on "The Conquest of Spa[ce] and Time," the development of the automobile and of the internal-combusti[on] engine is reviewed, and the history of car racing is traced from the earliest da[ys]. Statistical notes on mileage and cost of roads in Great Britain, on taxation, a[nd] on world speed records are included.

OGRAPHY. *" BODMER, Johann Georg, 1786–1864." (Gedenkfeier.)

A privately-printed account of the proceedings at the memorial meeting in Zurich, on 30 May, 1939, to honour the seventy-fifth anniversary of the death of the great Swiss scientist.

— BRUNTON, J " 1812–1899. John Brunton's Book, being the Memories of John Brunton, Engineer, from a manuscript in his own hand written for his grand-children and now first printed. Introduction by Professor J. H. Clapham." 1939. (Cambridge University Press.) 7*s.* 6*d.*

— *SAUL, A. R. L. " James Brindley and his Staffordshire Associations." Reprint from North Staffordshire Field Club Transactions. (Stoke-on-Trent.) 1939.

IDGES. FLAMENT HENNEBIQUE, R. " Photo-Elasticimetry: its application to the measurement of deformation of Bridges." 1939. (French Society of Civil Engineers, British Section, 82, Victoria Street, S.W.1.) No price.

— Government of India, Railway Department, Railway Board. " 19th Report of Bridge Standards Committee 3rd–11th Jan., 1939." 1939. (Delhi.) No price.

ILDING ESTATES. HOWKINS, F. " Development of Private Building Estates." 2nd ed. 1938. *Estates Gazette.* 16*s.* 6*d.*

RTOGRAPHY. RAISZ, E. " General Cartography." 1938. (McGraw-Hill.) 26*s.* 3*d.*

AL. Illinois University Engineering Experiment Station Circular, Series No. 39. " Papers presented at 5th Short Course on Coal Utilization." 1939. (Urbana.) 50 cents.

LUMNS. BEGG, R. B. H. " Charts for Concrete Column Design." 1939. Virginia Polytechnic Institution Engineering Experiment Station Series, Bulletin No. 40. (Blacksburg, Va.) 25 cents.

NCRETE. ANDERSON, P. " Square Sections of Reinforced Concrete under Thrust and Nonsymmetrical Bending." 1939. University of Minnesota Engineering Experiment Station Bulletin No. 14. (Minneapolis.) Gratis.

VINING ROD. MABY, J. C., and T. B. FRANKLIN. " The Physics of the Divining Rod." 1939. (Bell.) 21*s.*

A detailed physical explanation is given of dowsing, or divination by rod and pendulum, with a mathematical theory. Experimental investigations are described, and applications in the field are discussed.

YPT. BALL, J. " Contribution to the Geography of Egypt." 1939. Egypt Ministry of Finance, Survey and Mines Dept., publication. (Government Press, Cairo.) 10*s.* 6*d.*

— MINISTRY OF PUBLIC WORKS. " Means of Controlling and Distributing the Water-Supply of Egypt." (Cairo.) 1939. No price.

ECTRICAL MACHINES. CALVERT, J. F. " Amplitudes of Magnetomotive Force Harmonics for Fractional-Slot Windings of Three-Phase Machines." 1939. Iowa Engineering Experiment Station, Bulletin No. 142. (Ames, Iowa.) Gratis.

NGINEER, The. STEINMAN, D. B. " The Place of the Engineer in Civilization." A series of addresses, 1939. North Carolina State College Record, vol. 38, No. II. (Raleigh.) No price.

STIMATING. DAVIES, B. P. " Estimating for Buildings and Public Works." 9th revised ed. 1939. (Cardiff.) 25*s.*

ANS. *See* PUMPS.

RE AND FIRE PREVENTION. *MORRIS, C. C. B. " Fire!" 1939. (Blackie.) 12*s.* 6*d.*

HOUSING. WICHERS, H. E. "Low Cost Homes." 1939. Kansas State College Engineering Experiment, Station Bulletin No. 38. (Manhattan, Kansas) Gratis.

HYGIENE. FLETCHER, Sir B. and H. P. "Architectural Hygiene or Sanitary Science as applied to Buildings." 7th ed. 1939. (Pitman.) 12*s.* 6*d.*

INSTITUTION OF ELECTRICAL ENGINEERS. *APPLEYARD, R. "History of the Institution of Electrical Engineers." 1939. (I.E.E.) 18*s.* 6*d.*

MACHINES. TOFT, L., and A. T. J. KERSEY. "Theory of Machines." 4th ed. 1939. (Pitman.) 12*s.* 6*d.*

MAPS. *See* CARTOGRAPHY.

MATERIALS. WHITE, A. H. "Engineering Materials." 1939. (McGraw-Hill.) 30*s.*

This book is intended primarily as a text-book for engineering students who have had the usual grounding in chemistry, but it also includes a systematic presentation of recent advances in the field of materials, which is intended to interest practising engineers.

MECHANICS. THORNTON, D. L. "Mechanics applied to Vibrations and Balancing." 1939. (Chapman and Hall.) 36*s.*

The Author demonstrates the important bearing of unbalanced machinery in general, and of engines in particular, upon the vibratory motion of foundations and supports for such machinery, and discusses the design of buildings to resist earthquakes, including the problems of their foundations.

NATIONAL PHYSICAL LABORATORY. "Abstracts of Papers published in the year 1938." 1939. (H.M.S.O.) 1*s.*

PHOTO-ELASTICIMETRY. *See* BRIDGES.

PSYCHROMETRIC-READINGS. DROPKIN, D. "The Effect of Radiation on Psychrometric Readings." 1939. Cornell University Engineering Experiment Station Bulletin No. 26.) (Ithaca, N.Y.) 60 cents.

PUBLIC HEALTH. "Public Health Services, Congress and Exhibition. 6th Congress, 1938. Report." 1938. (13, Victoria Street, S.W.1.) 7*s.* 6*d.*

PUBLIC SPEAKING. TUCKER, S. M. "Public Speaking for Technical Men." 1939. (McGraw-Hill.)

PUBLIC UTILITY RATING. NASH, L. R. "Public Utility Rate Structures." 1933. (McGraw-Hill.) 26*s.* 3*d.*

PUMPS. O'BRIEN, M.P., and R. G. FOLSOM. "The Design of Propeller Pumps and Fans." 1939. University of California Publications in Engineering, vol. 4, No. 1. 1939. (Cambridge University Press.) 50 cents.

RADIATION. *See* PSYCHROMETRIC-READINGS.

REPAIR-SHOPS. DYER, H. J. "The Mechanic's Repair-Shop Manual." 1939. (P. Marshall.) 2*s.* 6*d.*

ROADS. MINISTRY OF TRANSPORT. Experimental Work on Roads. "Report for 1938–1939 of the Experimental Work on Highways (Technical) Committee." 1939. (H.M.S.O.) 2*s.* 6*d.*

SCIENCE. PLEDGE, H. T. "Science since 1500. A Short History of Mathematics, Physics, Chemistry, Biology." 1939. (H.M.S.O.) 7*s.* 6*d.*

In view of the increasing number of manuals on the history of special scientific subjects published by the Science Museum, this co-ordinating survey has been prepared for the use of students and research workers.

ENCE. TAYLOR, F. S. "A Short History of Science." 1939. (Heinemann.) 8s. 6d.

The scientific attainments of prehistoric man, of the Greeks and Arabians, of the Middle Ages, and of the modern world are reviewed, with the object of demonstrating the changing attitude of men to science, and of science to the external world, throughout the ages. More than fifty illustrations of historic scientific apparatus and experiments are included.

EET METAL WORK. COOKSON, W. and A. BOLD. "The Elements of Sheet Metal Work." 1939. (Tech. Press.) 6s.

EEL. SMITH, J. O. "The Effect of Range of Stress on the Torsional Fatigue Strength of Steel." 1939. Illinois University Engineering Experiment Station Bulletin, Series No. 316. (Urbana.) 45 cents.

IBER. D.S.I.R. Forest Products Research. "Handbook of Home Grown Timbers." 2nd ed. 1939. (H.M.S.O.) 2s.

— D.S.I.R. Forest Products Research. Cox, H. A: *Ed.* "Handbook of Empire Timbers." 1939. (H.M.S.O.) 3s. 6d.

TER PURIFICATION. COX, C. R. "Water Purification for the Practical Man." 1938. (Case-Shepperd Pub'g. Corpn., 24, West 40th St., New York City.) 6s.

A handbook of laboratory practice in the waterworks plant, intended for persons who have not had special training in chemistry and bacteriology. The fundamental principles in the supervision of public water-supplies and the control of water-purification equipment are reviewed, and the practical application of test results in routine control is explained.

TER SUPPLY. HOOVER, C. P. "Water Supply and Treatment." 3rd ed. 1938. Bulletin No. 211, National Lime Association, Washington, D.C. 50 cents.

This is a practical discussion of water-supplies and methods of treatment, for the use of city officials, civic organizations, and industrialists, and a work of reference for plant operators, engineers, and students, based upon operating experience at Columbus, Ohio.

See also EGYPT.

RELESS. INGRAM, G. W. "Radio Interference Suppression." 1939. (*Electrical Review.*) 5s.

(* *The foregoing books, with the exception of those marked with an asterisk, may be rowed from the Loan Library.*)

LOCAL ASSOCIATIONS.

MEETING.

Notice of the following meeting of the Glasgow and District Associatio
has been received, and any inquiry regarding it should be addressed
Mr. William McGregor, B.Sc., Assoc. M. Inst. C.E., Engineering Depar
ment, The University, Glasgow, W.2.

1940.

Jan. 26.—Vernon Harcourt Lecture. "The Construction of Deep-Water Quay by A. C. Gardner, M. Inst. C.E. (To be delivered at the Institution of Engine and Shipbuilders in Scotland, 39, Elmbank Crescent, Glasgow, at 6.30 p. Tea at 6 p.m.)

REPORTS.

Edinburgh and District Association.

On Wednesday, 13 December, a lecture, illustrated by lantern slid on "German Waterworks Practice" was given by Mr. John Bowma M. Inst. C.E.

Northern Ireland Association.

On Monday, 27 November, Mr. N. M. Brydon, B.Sc., M. Inst. C. read a Paper on "The Engineer and Post-War Reconstruction."

Yorkshire Association.

The following meetings have been held :—Saturday, 25 Novemb when there was a general discussion on "A Code of Practice," introdu by Professor J. Husband, M.Eng., M. Inst. C.E., Mr. H. C. Husband, B.E and Mr. G. McLean Gibson, O.B.E., Assoc. MM. Inst. C.E.; Saturd 9 December, when a Paper on "The York Passenger Station Extensio was read by Mr. H. Ormiston, B.Sc., Assoc. M. Inst. C.E.